AUG 26 1924

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CXVIII.—No. 3059.] *LONDON: FRIDAY, AUGUST 15, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd.,
ROCHESTER.
Steam & Crude Oil Road Rollers, &c. 1869

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS.
See Advertisement page 36.
PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected. Tested and reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." Great Eastern Road, Stratford, E. 15. 1794

Penningtons, University
TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

See's Patent Hydro-Pneumatic Ash Ejector
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS. Od 3382
Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helen's, Bishopsgate, E.C. 3.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

Spencer-Hopwood & Kirke
PATENT BOILERS. *See page 67, Aug. 8.* 1994
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

General Smiths' Work.
FELLOWS BROS., LTD., 9158
CRADLEY HEATH, STAFFS.

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 1914
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED
Duckham's Patent Suspended
WEIGHING MACHINES—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 15. 1715

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 1867
Telegrams:—"Cylinders," Birmingham.

Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 08179

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & Co., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 2213

The Mitchell Conveyor and
TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
Atlantic House,
45-50, Holborn Viaduct,
London, E.C. 1.
Telegrams: "Micontraco, Cent, London."
Telephone: Holborn 2622. 1713

Dredging Plant—
For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes.
ARTHUR R. BROWN,
84, New Broad Street, London, E.C.2.
Telephone: London Wall 3413. 1814

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Regent Guillotine Shears and Power Presses
FOR SHEET AND PLATE WORKING.
THE REGENT SHEET METAL MACHINE TOOL CO., LTD.,
REGENT WORKS, WAKEFIELD. 2012

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisements, pages 35 and 62.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 27. 1872

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 1828

Machinery, Plant, &c.

Nearly New, STEEL LANCASHIRE BOILER, 30 ft. by 9 ft., reinsurable at 100 lbs. steam working pressure, complete with steam and furnace fittings, etc.

COCHRAN VERTICAL BOILER, 16 ft. 3 in. by 7 ft. 6 in. diameter, reinsure 80 lbs. pressure.

LOCO. TYPE BOILER, barrel 4 ft. 7 in. long by 3 ft. diameter, reinsure 80 lbs. pressure.

New HYDRAULIC BRICK PRESS, with rotary table, for making two magnesite bricks simultaneously, by Brinck & Hubner.

Set of HORIZONTAL THREE-THROW HYDRAULIC PUMPS, 3½ in. rams, 12 in. stroke, working pressure 1500 lbs., by Hy. Berry & Co.

HYDRAULIC ACCUMULATOR, 9½ in. ram, 10 ft. stroke, 700 lbs. working pressure, 18 weight segments, 1½ in. iron tier.

Two Nearly New Tangye's MOTOR 'BUS TYRE PRESSES, to give a pressure of 60 tons, ram, 7 in. diameter, 24 in. run out.

Two 2 ft. gauge 4—6—0 SIDE TANK LOCOMOTIVES (Baldwins), new 1917, cyls. 9 in. by 12 in.; suitable 175 lbs. pressure; ready for work.

One 3 ft. gauge 0—4—0 SADDLE TANK LOCOMOTIVE (Bagnall), new 1919; outside cyls. 7 in. dia. by 12 in.; suitable 150 lbs. pressure; ready for work.

One 2 ft. gauge PETROL LOCOMOTIVE, 15 h.p.; new condition; Coventry Simplex engine, Simms high-tension mag., Zenith carburettor; a first-class loco., ready immediate work.

Two 12-ton "WILSON" LOCO. STEAM CRANES, with 27 ft. jibs; 4 ft. 8½ in. and 8 ft. 3 in. gauges; suitable 90 lbs. pressure.

Thos. W. Ward, Ltd.,
ALBION WORKS, SHEFFIELD. 1726
Palace of Engineering, Wembley, Stand 189. Bay 23-24. Avenue 1-2.

Babcock & Wilcox Land
TYPE BOILER, 40 tubes, new 1909, 160 lbs. w.p.
CORNISH BOILER by Woodhouse & Mitchell, 20 ft. by 6 ft. dia., 100 lbs. w.p.
Economic Type BOILER by Davey Paxman, 12 ft. by 8 ft., 140 lbs. w.p.
Dry Back Marine Type BOILER, by Fraser, 13 ft. by 11 ft., 100 lbs. w.p.
Small Marine Type Dry Back BOILER, 5 ft. by 5 ft. 6 in., 160 lbs. w.p.
135 HP. Robey Cross Compound Drop Valve STEAM ENGINE.
140 H.P. Garratt Superheated STEAM ENGINE and BOILER with all accessories.
Horizontal STEAM ENGINE by Marshall, Cyl. 13 in. dia. by 27 in. stroke.
Ditto "MF" Type, Cyl. 16 in. diameter by 20 in. stroke.
HARRY H. GARDAM & CO., LIMITED, Staines. F 579

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 2277

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1316
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 54, Aug. 8. 2402

HEAT INSULATION.
CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Aug. 1.

PROPELLERS
AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
PHILADELPHIA, U.S.A.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 2329

WAYGOOD-OTIS LIFTS 2130
54 & 55, FETTER LANE, LONDON, E.C.4, 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 60, Aug. 1.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

PATENTS AND DESIGNS ACTS, 1907 & 1919.

Notice is Hereby Given that

JOHN PELL NORTHEY, British Subject, of 502, Ryrie Building, Yonge Street, in the City of Toronto, County of York, Province of Ontario, Dominion of Canada, seeks leave to amend the Specification of Letters Patent No. 209122, granted to him for "Improvements in Sound Producing Devices."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 7th August, 1924.

Any person, or persons, may give notice of opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C.2, within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General. F 551

In The High Court of Justice,
Chancery Division.

FORD MOTOR CO. (ENGLAND) LIMITED, and FORD MOTOR CO., of Detroit, U.S.A. Plaintiffs
versus
STENTOPHONE MOTOR ACCESSORIES (1921) LIMITED, and
AUSTIN HAMILTON TRELOGGAN. Defendants.

THE FORD MOTOR CO. (ENGLAND) LIMITED and THE FORD MOTOR CO. of DETROIT, U.S.A.,

Hereby Give Express Notice

and WARNING that in the above-named action a perpetual injunction was on the 27th May, 1924, granted restraining the Defendants from

(1) using as a name, trade mark, description, or address of any business carried on by them the manufacture or sale of parts of or accessories for Motor Vehicles or as part of such name, trade mark, description or address, the words "Ford," "Stentoford," "Superford," "New Ford," "Fordacks," or any of them, or any word including the word "Ford" calculated to lead to the belief that such business is, or is connected with the business of the plaintiffs or either of them and from selling, offering for sale or advertising parts of or accessories for Motor Vehicles (not being parts or accessories of the manufacture or merchandise of the Plaintiffs or either of them) as Ford accessories, Ford parts, Ford replacements or the like or under any of the words aforesaid or under any description which include the name "Ford" except as a *bona fide* description of the goods indicating that they are suitable for use on Ford cars such as "for Ford cars" "for Fords" or the like; and from passing off or attempting to pass off such parts or accessories as and for the Plaintiffs' parts.

(2) Infringing the copyright in the price lists of the Ford Motor Co. (England) Ltd.

As similar user of the name "Ford" either separately or in combination with other words or name is believed to have been extensively used throughout the United Kingdom for the purpose of passing off the goods of other manufacturers and dealers for the products and merchandise of the Ford Companies.

The Ford Companies now give express notice and final warning that they will proceed according to the law against any person or persons whatsoever who are found to be selling or offering or advertising for sale or in any other manner passing off or attempting to pass off or representing as the manufacture and merchandise of the Ford Companies or either of them under the name "Ford" either separately or in combination with any other word or name any parts or Accessories for Motor Vehicles which are in fact the manufacture and product of persons other than the Ford Companies.

Dated this 11th day of August, 1924.
(Signed) F. O. S. LEAK & CO.,
of 6, John Dalton Street, Manchester.
Solicitors for the Ford Motor Co. (England) Ltd., and the Ford Motor Co., of Detroit, U.S.A. F 592

University of Manchester.

FACULTY OF SCIENCE.

Departments of Civil, Mechanical and Electrical Engineering. COMPLETE COURSES OF STUDY, extending over three years, lead to the University Degree in Civil, Mechanical and Electrical Engineering. Students who have shown exceptional ability during the first year are admitted to the Honours Courses. The Session commences on the 2nd October. A prospectus giving full particulars may be obtained on application to the INTERNAL REGISTRAR.

DEPARTMENTS.

Professor A. H. Gibson, D.Sc., M.Inst.C.E., M.I.Mech.E. (Engineering).
Professor Robert Beattie, D.Sc., M.I.E.E. (Electrical Engineering).
Professor L. J. Mordell, B.A. (Mathematics).
Professor Arthur Lapworth, D.Sc., LL.D., F.R.S. (Chemistry).
Professor W. L. Bragg, M.A., F.R.S., Nobel Laureate (Physics).
Professor F. C. Thompson, B.Sc., D.Met. (Metallurgy).
Professor O. T. Jones, M.A., D.Sc. (Geology).

Students specialising in Water Supply and Irrigation, work under the direction of Associate Professor Sandeman, M.Sc., M.Inst.C.E. F 547

University of Manchester,

DEPARTMENT OF ELECTRICAL ENGINEERING.

Departments of Civil, Mechanical and Electrical Engineering. Full particulars of these courses will be forwarded on application to the INTERNAL REGISTRAR. The Session commences on October 2nd. F 548

University of Bristol.

FACULTY OF ENGINEERING.

The SANDWICH SCHEME provides academic training for the B.Sc. DEGREE OF ENGINEERING, combined with works experience with one of 20 leading engineering firms in the United Kingdom. Prospectus from the REGISTRAR, Merchant Venturers' Technical College, Bristol. F 549

The Royal Technical College, GLASGOW.

DEPARTMENTS OF ENGINEERING.

MECHANICS AND MECHANICAL ENGINEERING:—
Professor Alexander L. Mellanby, D.Sc., M.I.Mech.E.
Associate Professor Wm. Kerr, Ph.D., A.R.T.C.
ELECTRICAL ENGINEERING:—
Professor Stanley Parker Smith, D.Sc., M.I.E.E., A.M.Inst.C.E.
CIVIL ENGINEERING:—
Professor George Moncur, B.Sc., M.Inst.C.E., M.Amer.Soc.C.E.
MINING ENGINEERING:—
Professor Daniel Burns, M.Inst.M.E.

Complete courses of instruction are provided, qualifying for the Diploma of the College (three sessions) and for the degree of B.Sc. in Engineering of Glasgow University (four sessions). Composition fee 25 guineas per annum.

Session 1924-25 begins on Tuesday, September 23rd.

Calendar, by post 3s., and Prospectus, gratis, may be obtained on application to the DIRECTOR. F 508

University of Birmingham.

FACULTY OF SCIENCE.

ENGINEERING DEPARTMENTS.

I.—Mechanical Engineering.
Chance Professor: F. W. Burstall, M.Sc., M.A. (Cantab.), M.Inst.C.E. M.Inst.M.E.
Lecturer: R. C. Porter, M.Sc. (Vict.), A.M.Inst.C.E.
Demonstrator: S. J. Ellis, B.Sc., A.M.I.C.E.
Lecturer on Machine Design: F. H. Boden, B.Sc.
Assistant Lecturer on Machine Design: H. P. Dean, B.Sc.

II.—Civil Engineering.
Beale Professor: Cyril Batho, D.Sc., B.Eng.
Lecturers: R. C. Panton, M.Sc.
H. W. Coultas, M.Sc.
T. H. P. Veal, B.Sc.
Lecturer on Town Planning: W. Haywood.

III.—Electrical Engineering.
Professor: William Cramp, D.Sc.
Lecturer: E. J. Kipps, M.Sc., M.Inst.E.E.
Assistant Lecturers and Demonstrators: O. R. Randall, M.Sc.
G. M. Harvey, M.Sc., B.Eng.

The FULL COURSES EXTEND OVER FOUR YEARS, and students who enter after matriculation and pass sucessfully the examinations at the end of each year will BE ENTITLED TO THE DEGREE OF BACHELOR OF SCIENCE in Engineering.

THE SESSION 1924-25 COMMENCES ON OCTOBER 6th, 1924.

For detailed syllabus of the Faculty with full particulars of University Regulations, Lecture and Laboratory Courses, Fees, etc., apply to the REGISTRAR. F 444

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, Trafford Chambers, 58, South John Street, LIVERPOOL. 1993

Engineering Salesmanship and Sales Management.—Write for

brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2282

Pitman's Correspondence

Course in ENGINEERING DRAWING.—To succeed in any branch of Engineering (Civil, Mechanical, Electrical, Hydraulic, Textile or Motor Engineering, etc.) you must be able to make a WORKING DRAWING. My special postal course in Mechanical Drawing and Machine Design teaches you the latest and most modern Drawing Office practice. Students and workmen employed in the daytime, advance rapidly under my interesting and practical system of teaching by post. If you have ambition and desire a more congenial and lucrative occupation let me help you. Enrol now for the complete course, fee Three guineas, or by instalments. Also day and evening tuition in Office. ESTABLISHED IN 1894.—P. PITMAN, M.I.Mech.E., 25, Victoria St., London, S.W.1. 2497

TENDERS.

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

BRIDGEWORK (1 30 ft. clear span, 88 40 ft. clear spans).

For each copy of the Specification a fee of 20s. will be charged, which fee is not returnable. Tenders, enclosed in sealed envelopes, addressed to "The Chairman and Directors," and endorsed "Tender for Bridgework," must be delivered at the Company's Offices not later than Twelve Noon on Friday, 29th August, 1924. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

The work is urgently required.

By Order of the Board.
F. C. FRANKS,
Secretary.

199, Gresham House,
Old Broad Street,
London, E.C. 2.
11th August, 1924. F 571

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

THE ROHILKUND AND KUMAON RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

STEEL MATERIAL

as per Specification to be seen at the Company's Offices.

Tenders, addressed to the undersigned, and marked "Tender for Steel Material," or as the case may be, with name of firm tendering, to be lodged not later than Noon on the 1st day of September, 1924.

For each Specification a fee of 10s. will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.
Secretary.

237, Gresham House, Old Broad Street,
London, E.C.2.
August 8th, 1924. F 558

METROPOLITAN ASYLUMS BOARD.

TO BOILER COVERERS.

The Board invite

Tenders for the Covering of

BOILERS, STEAM CONDENSE and FEED MAINS, etc., with Non-Conducting Composition at the Brook Fever Hospital, Shooters Hill, S.E. 18, in accordance with the Specification prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification and Form of Tender, may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m. on Thursday, August 14th, 1924, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona-fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification has been returned.

Tenders addressed as noted on the Form must be delivered at the Office of the Board, not later than 2.30 p.m. on Wednesday, 27th August, 1924.

(By Order) G. A. POWELL,
Clerk to the Board.
F 567

BOMBAY, BARODA & CENTRAL INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Wednesday, 27th August, 1924,

Tenders for the Supply of:—

1. STEEL MATERIAL (Plates, Angles, Squares, etc.).
2. VACUUM BRAKE HOSE PIPES and WASHERS.
3. STEEL BOILER TUBES.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W.1.
11th August, 1924. F 573

DREDGER.
BRITISH MANUFACTURE ONLY.

The Lee Conservancy Board invite

Tenders, Designs, and Specifications for a STEAM LADDER BUCKET

DREDGER, 80 ft. long, by 13 ft. Beam, depth middle line 4 ft. 6 ins., draught not to exceed 3 ft., to dredge to a depth of 12 ft. and raise not less than 65 tons per hour, to load into barges 4 ft. 6 ins. above water line and to be forward cutting to cut its own flotation. The framing and gear to be easily lowered so as to pass under bridges 6 ft. 9 in. above water line.

The hull to be of Steel to Lloyds' Specification with accommodation for two men to sleep on board. State time of delivery afloat ready for work on the Lee Navigation at Bromley Lock, Bow, London, E.

The Board do not bind themselves to accept the lowest or any Tender and all designs offered are to be at the expense of the persons tendering.

Tenders, Designs and Specifications giving full particulars to be delivered in sealed envelopes marked "Dredger," not later than September 29th, 1924, to

CHARLES N. TWEEN, M.Inst.C.E.,
Engineer & Manager to the Board,
Enfield Lock, Middlesex. F 519

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, ETC., are prepared to receive

Tenders before Eleven

a.m. on Tuesday, 2nd September, 1924, for the SUPPLY, DELIVERY and INSTALLATION of 150 K.V.A. MOTOR ALTERNATOR SET, etc., at the National Physical Laboratory, Teddington.

Forms for Tender, etc., may be obtained application to the SECRETARY (Contracts Branch), H.M. Office of Works, etc., King Charles Street, Westminster, London, S.W. 1. F

THE PUBLIC WORKS DEPARTMENT OF THE SUDAN GOVERNMENT are calling for

Tenders for the Supply

the following MATERIALS in connection with the Port Sudan Water supply works:—

One 500 ton Elevated Water Tank.
17 miles of 6 in. Mild Steel dipped pipe, fittings
15 6 in. C.S. Gate Valves.
2565 ft. 10 in. C.I. pipe, Class B, with fittings and valves.
5157 ft. 8 in. C.I. pipe, Class B, with fittings and valves.
33,399 ft. 2 in. C.I. pipe, Class B, with fittings and valves.
29 Fire Hydrants.
20 Public Standposts with spring taps,
126 Surface boxes.
1 Positive water meter.
14,436 ft. 6 in. C.I. pipe, Class D, with fittings and valves.
17 tons of Pig Lead with gaskin for joints making.

Specifications may be seen at the offices of Messrs. A. BEEBY THOMPSON & PARTNERS, 18, Southampton Lane, London, E.C.4. where Tenders will be received until Noon, September 1st. F

PLYMOUTH CORPORATION WATERWORKS.

BURRATOR RESERVOIR ENLARGEMENT.

TEMPORARY BRIDGE.

The Water Committee invite

Tenders for the Provision of

the necessary MATERIAL, ERECTION, TAKING DOWN and REMOVAL of a BRIDGE to be placed across the Burrator Reservoir, situate about 12 miles from Plymouth and about 1½ miles from Dousland Station, G.W.Rly.

Form of Tender, Specification and conditions may be obtained on application to the Water Engineer, Plymouth, accompanied by a deposit of two guineas which will be refunded on receipt of a *bona fide* Tender.

Sealed Tenders, endorsed "Tender for Bridge," must be delivered to the undersigned not later than Monday, September 22nd, 1924.

The Committee do not bind themselves to accept the lowest or any Tender.

FRANK HOWARTH, M.Inst.C.E.,
Water Engineer.

Stonehouse Town Hall,
Plymouth.
August, 1924. F

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

THE ROHILKUND AND KUMAON RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

(A) 2350 HELICAL AND VOLUTE SPRINGS.
(B) 1090 BUFFERS FOR CARRIAGES AND WAGONS,

as per Specifications to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Helical and Volute Springs" or as the case may be, with name of firm tendering, to be lodged not later than Noon on the first day of September, 1924.

For each Specification a fee of 10s. will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.
Secretary.

237, Gresham House, Old Broad Street,
London, E.C. 2.
12th August, 1924. F

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 24/08—
22,000 VOLT. INSULATORS.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona-fide* Tender. A fourth copy, and any further copies, will be supplied for the sum of 10s. 6d. each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £100 is to be lodged with Tender.

The Specification may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 20th October, 1924.

R. LIDDELOW,
Secretary. F

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON—GOLDSMITHS' COLLEGE, NEW CROSS, LONDON, S.E. 14

Applications are Invited for the POST of EVENING LECTURER in Theory and Design of Structures, Mondays and Thursdays, from 7.0 to 9.30. Remuneration will be at the rate of £2s. per evening. For forms of particulars on application, and a more detailed statement of duties, apply to THE WARDEN, Goldsmiths' College. F 522

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON, S.W. 7.

Applications are Invited for the POST of DEMONSTRATOR in the Mathematics and Mechanics Department of the Royal College of Science (some engineering experience essential), salary £300 per annum. Full particulars on application.—Candidates' applications, addressed to the SECRETARY at the College, must be received not later than 5th September, 1924. F 546

UNIVERSITY OF LONDON—GOLDSMITHS' COLLEGE, NEW CROSS, LONDON, S.E. 14.

The Services of a First-class working MECHANIC are REQUIRED, to prepare and keep in good condition, tools and apparatus for evening class work, and to otherwise assist the Head of the Engineering Department as he may direct.

Applicants must be experienced in precision work at the bench and machines, and have had some technical training.

Apply, in writing only, stating qualifications, experience and wages expected, to THE WARDEN, Goldsmiths' College. F 521

Wanted—Man Experienced in the design of boiler houses including the supervision of detail drawings, specification writing and negotiating of technical details with manufacturers of equipment. Man must be competent to assume complete responsibility for a job from its inception to its completion and operation. In reply Applicants should give names of firms they have served with inclusive dates of service, names of projects of note on which they have worked, with a statement of their duties in connection with same; details of education including Diplomas or Degrees they hold; salary expected; when available and references. A Photograph is also desirable. Location London.—Address, F 583, Offices of ENGINEERING.

Shift Engineer Required by the GOVERNMENT OF NIGERIA, for the ELECTRIC LIGHT DEPARTMENT, for two tours of from 12 to 18 months each, with possible permanency. Salary £400-£12-£500 a year. Outfit allowance of £45 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, age 25 to 35, should have had a thorough mechanical training and possess electrical and power station experience, be competent to take charge of a six hour shift in Power Station and be responsible for the efficient running of the machinery and boilers, including Diesel engines, feed pumps and other auxiliaries. They must have had experience in the working of Babcock boilers fitted with mechanical stokers and with Bellis and Morcom's high speed engines, and should be competent to effect running repairs. Preference will be given to those who, in addition, have had seagoing experience and hold a Board of Trade certificate.—Apply at once by letter, stating age and particulars of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/12937. F 553

Technical Instructor REQUIRED by the GOVERNMENT TECHNICAL SCHOOL, FEDERATED MALAY STATES, for four years' service. Salary $400 a month, rising to $475 by annual increments of $25 a month, plus a strictly temporary cost of living allowance amounting to 10 per cent. of salary in the case of single men, and 20 per cent. for married men. The Government rate of exchange is now 2s. 4d. to the dollar, but the purchasing power of the dollar in Malaya is at present considerably less than that of 2s. 4d. in the United Kingdom. On the satisfactory termination of agreement a bonus of one month's salary will be paid. Free passages provided. Candidates, preferably single, aged 26 to 35, should have graduated at one of the Colleges granting a diploma or degree exempting the holder from passing sections (A) and (B) of the A.M.I.C.E., examination, and should have had at least two years' experience as technical instructors. Must be competent to instruct junior officers or technical subordinates of the Public Works Department, Railways, Posts and Telegraphs and Survey Departments in the arts of

(a) Surveying, levelling and the taking out of quantities.
(b) The Drawing and preparation of plans and estimates.
(c) Organising and controlling labour and the supervision of works under construction and expenditure thereon.
(d) Storekeeping and care of machinery and plant.

Apply at once by letter, stating age, whether married or single, and giving particulars of qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting clearly at head of application M/13002. F 554

Works Manager Required for works near London. Applications will only be considered from Britishers with considerable experience in similar positions, holding the highest credentials and having preferably practical experience with blast furnaces, lime kilns, and grinding and conveying plant, with knowledge of works chemistry, and capable of taking entire control of personnel, output and maintenance. Permanent job with commencing salary of £600 p.a. Applicants should state concisely their previous experience, with dates.—Address, F 562, Offices of ENGINEERING.

Testing 2137

A Monthly International Journal Devoted to the Field of Testing Materials, Structures and Machinery.

Edited with the Collaboration of Experts in All Industrial Countries of the World.

Subscription, $15.00 per Annum

PULLMAN PUBLISHING COMPANY
Pullman Building, Madison Square Station NEW YORK, U.S.A.

Manager Wanted for General Engineering Brass and Iron Foundry Works on North East Coast presently employing about 450 hands.—Address, F 517, Offices of ENGINEERING, stating age, experience, references and salary required.

The Royal Air Force REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, ENGINE DRIVER FITTERS, POWER STATION ENGINEERS and WIRELESS OPERATORS. Age limits 18 to 30. Pay from 2s/6d. to 3s/6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. F 214

A North of England Engineering Firm has OPENINGS for training in their special business TWO YOUNG MEN with the idea of occupying positions at home or abroad. Applicants must have had a public school education, have been trained as engineers, and must be between the ages of 21 and 26 years. Apply, stating particulars of education and training and initial salary required.—Address, F 591, Offices of ENGINEERING.

Wanted, Brown & Sharpe Automatic SETTER-UP, experienced, to take charge of small shop.—Write stating age, experience and salary required, BOX 317, WILLINGS, 30, King Street, Covent Garden, W.C. 2. F 568

Several Senior and Junior DRAUGHTSMEN WANTED for Aeronautical work by S. E. SAUNDERS, LTD., East Cowes, Isle of Wight. Apply, stating experience and wages desired. F 502

Draughtsman Required by Engineering firm in Midlands. One with general engineering knowledge preferred. Must be accurate and reliable. Write, stating age, experience and Salary required.—Address, F 578, Offices of ENGINEERING.

Draughtsman Wanted for Engineering Works in Bombay, age not to exceed 30. Single man preferred. Must be proficient in constructional work. Five years' agreement.—Write giving full particulars of career to Z.T. 247, c/o DEACONS, Leadenhall Street, E.C. 3. F 587

Draughtsman Required, Aged about 22/25, well experienced in Mechanical Engineering work, such as Steam and Diesel Plants, Pumping and Ventilating Plants, etc. Must be well educated and have irreproachable testimonials.—Address, stating full particulars of experience and salary, F 594, Offices of ENGINEERING.

Draughtsman Required temporarily for Structural and General Railway work. Apply, stating age, full particulars of experience and salary required.—Address, F 593, Offices of ENGINEERING.

MINISTRY OF TRANSPORT.

Applications are Invited for a Temporary APPOINTMENT as a Civil Engineering DRAUGHTSMAN under the Roads Department of the Ministry of Transport, at an inclusive wage not exceeding five guineas per week, according to qualifications.

Candidates should have a good workshop experience of constructional engineering and wide drawing office experience in constructional steel work. A knowledge of design and calculations is essential.

Applications, stating age, experience and qualifications, should be addressed to the ESTABLISHMENT OFFICER, Ministry of Transport, 6, Whitehall Gardens, London, S.W. 1, not later than Friday, 29th August, and copies of two recent testimonials should also be furnished. Preference will be given to candidates who have served in H.M. Forces. F 590

SITUATIONS WANTED.

Engineering Works Manager DESIRES Responsible POST, theo. and pract. mechanical engineer, Hons. 22 years first-class firms, general engineering, tool-room and modern machine shop exp., mass production methods. Knowledge works progress and planning, D.O. and general office exp. Control labour, keen, reliable, good refs, mod. sal.—Address, F 596, Offices of ENGINEERING.

B. Sc. (Civil Engineering), 25, ex-officer, requires experience with General Contractor. Prospects and remuneration essential. —Address, F 577, Offices of ENGINEERING.

B. Sc. Eng. Lond. Ind. Hons., A.C.G.I., A.M.I.Mech.E., 2 years' shops engine builders, D.O. exp., ex-service, 24, WANTS POST tech., asst. or other progressive capacity.—Address, F 564, Offices of ENGINEERING.

A.M.I.C.E., (37), Experienced in Harbour construction works, commercial buildings and foundations, DESIRES an APPOINTMENT, preferably at home in office or on works.—Address, F 550, Offices of ENGINEERING.

Young Engineer (21½), 3 yrs. pupilage well-known firm of motor vehicle and marine engineers (including D.O. and laboratory); additional experience, engine and motor-boat testing. Passed Grad. and As.t. Memb. Examination of Inst. Mech. Engs., Desires Suitable Appointment, home or abroad, moderate salary if good prospects. —Address, F 585, Offices of ENGINEERING.

Engineer (26), First-class B.O.T., experienced Turbines, Oil fuel, and latest Auxiliaries; 6 mths. Drawing Office, At present assisting Engineer M.I.Mech.E., but desires wider experience, offers services to Consulting Engineer or reputable firm. Highest references. Immediate services available.—Address, F 595, Offices of ENGINEERING.

Draughtsman (27), Married, 5 yrs. shops and D.O. exp., Ed. Public School. Steam and I.C. engines, ex. refs., SEEKS POST. Salary £3 15s. 0d.—F 586, Offices of ENGINEERING.

Draughtsman, Mechanical (24), SEEKS SITUATION offering prospects. Good general experience. Capable of seeing job right through. Good technical knowledge.—C., 176, Camberwell New Road, S.E.5. F 559

Draughtsman (40), Wide Experience in design and estimating all classes of cranes, accustomed charge of office, DESIRES POST. First-class references.—Address, F 576, Offices of ENGINEERING.

To Firms Manufacturing Tanks, Gas Plant, Structural Work, etc. General Foreman Boilermaker DESIRES CHANGE. Good organiser, Practical Man. 11 years' Foreman with up-to-date Firms. Age 37. Would consider joining small progressive Firm, where £200 could be invested.—Address, F 497, Offices of ENGINEERING.

Foreman Bridge Builder REQUIRES SITUATION, home or abroad, used to erecting Heavy and Light Steel Structures, Foundations, Reinforced Concrete, Pile Driving, Damming, Centreing, Timbering. Willing to quote for Erections, Sub-Contract. Anywhere.— P. 71, Crowland Road, Tottenham, N. 16. F 552

WORK WANTED.

J. Kirkaldy, Limited. WORKS: BURNT MILL, HARLOW, ESSEX. 2328

We are organised to produce castings from 2 lbs. to 2 tons. Cast-iron, Semi-steel, and Non-ferrous castings. Coils of every description, Steel and Copper. Sheet Metal Work. Over 40 years' experience is at your service. Send your enquiries along.

Drawings, Blue Prints and TRACINGS OF ANY DESCRIPTION. Special Machine Tools, Jig and Fixture Design a speciality. Prompt attention.—HERBERT R. COWLEY, Engineer, Draughtsman and Designer, 4, Berens Road, Kensal Green, N.W. 10. 'Phone: Willesden 2109. F 597

WANTED, &c.

Partner in Firm of Engineers' Merchants, now visiting England from South Africa and with old connection amongst Collieries, Sugar Mills, and General Industrial Concerns, is DESIROUS of NEGOTIATING with Manufacturers who desire direct representation in South Africa.—Address, F 560, Offices of ENGINEERING.

India, Burmah and Ceylon. Experienced Traveller (Practical Engineer) with old and influential business connections, offers whole or part share of paid REPRESENTATION. Excellent opportunity to Firms of repute desiring an introduction or development of their interests amongst Railways, Municipalities, and Importers. —Address, F 565, Offices of ENGINEERING.

Well-known Continental Engineering Firm with London Office, specialising in Water and Steam Turbines, Turbo-Blowers, Compressors, Pumps, etc., wishes to APPOINT influential and experienced AGENT for Ireland. Write fully in first instance stating experience and past and present activities.—Address, F 566, Offices of ENGINEERING.

Danish Manufacturer of Patented Soot Blowing Apparatus, competitive in price, extensively used by the Danish Navy, State Railways and leading Steam Ship Companies, desires to LICENCE or SELL the PATENT RIGHTS in Great Britain, or to make other arrangements for the purpose of developing the sale.
Address, F 525, Offices of ENGINEERING.

Consulting Engineer, with central office and staff in Glasgow, having first-class connection with general and marine engineers, is OPEN to REPRESENT a firm of repute.—Address, F 537, Offices of ENGINEERING.

Wanted, "Izod" Impact Testing MACHINE 120 ft. lbs. Second-hand. —Write full particulars, condition, price, etc., BOX 316, WILLINGS, 30, King Street, Covent Garden, W.C. 2. F 569

Wanted, Two No. 0 and One No. 2. Brown & Sharpe AUTO SCREW MACHINES, or Brown & Sharpe AUTO-FORMING MACHINES, Second hand.—Write, full particulars, condition, price, etc., BOX 315, WILLINGS, 30, King Street, Covent Garden, W.C. 2. F 570

PARTNERSHIPS.

IF YOU ARE SEEKING
A Partner or Partnership
or wish to Buy or Sell a BUSINESS or WORKS
Write:—
Wheatley Kirk, Price & Co,
46, Watling Street, LONDON, E.C. 4.
ESTABLISHED OVER SEVENTY YEARS. 1875

AUCTION SALES.

Wheatley Kirk, Price & Co.
(Established 1850)
Auctioneers
AND VALUERS OF 1875
NGINEERING WORKS, PLANT AND STOCK
46, WATLING STREET, LONDON, E.C. 4.
16, ALBERT SQ., MANCHESTER. 36, COLLINGWOOD ST., NEWCASTLE-ON-TYNE.
Telephones & Telegrams at each Address.

FOR SALE.

To Boiler Buyers.—Vertical, Loco., Cornish, Launch, Field Tube. Air Receivers & Feed-water Heaters. —GRANTHAM BOILER & CRANK CO., LD., Grantham.

A Large Quantity of New WIRE ROPES at low prices.—THE LONDON ELECTRIC FIRM, Croydon. F 584

For Sale, Electrical Material, 440 volts (motors and transformators). American tools: Steel rules, micrometers, files, taps and ties, drills, hammers, reamers, cutters and so on. Address: Liquidation de MEHUN-sur-YEVRE (Cher) France. F 524

For Sale, Motor-Driven Air COMPRESSOR, by Bellis & Morcom. 1000 cubic ft. per min. 100 lbs. pressure, with 500 volt D.C. motor.—THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. D 221

Diesel Engines, 300, 530, 800, 1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock.
HICK DIESEL OIL ENGINES, LTD., 70, Queen Street, E.C. 4. 2043

Armstrong Whitworth Triple Geared LATHE, centres 16 in., bed 36 ft. surfacing, sliding and screwcutting. Little Used. Modern tool.—Address, F 462, Offices of ENGINEERING.

For Sale, Motor Generator, by Lancashire Dynamo Co., Ltd., 1920, Comprising, 480 volt, D.C. Motor, coupled to 105 volt, 820 ampere compound interpole Generator, complete with Switchboard.
THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. C 475

Business For Sale. Old Established General Brass Finishing Works, freehold, modern plant, newly decorated, living accommodation. As a going concern. Low price.—G. H. CROCKITT, 544, Commercial Road, Stepney, E. 1. F 588

For Sale, &c., continued on page 4.

West Hartlepool.—For Sale

as a going concern, excellent Blacksmiths, Whitesmiths and General Engineering Business together with Land, Buildings, Machinery, all necessary tools and equipment. Excellent opportunity.

W. T. WALTON, Junr., F.A.I.,
Auctioneer & Estate Agent,
Scarborough Street,
W. HARTLEPOOL. F 555

URGENT—SPACE REQUIRED.

£1750 is the Price of 1000

Kw. (2-500 Kw.) Parsons TURBINE GENERATING SETS, 230 Volts D.C., with Klein Condensing Plant and spare armature complete. Steam 150 lbs.

Also available 600 Kw. Brush-Parsons EXHAUST TURBINE SET, 230 volts D.C., and H.C.C.-Willans EXHAUST TURBINE SET, 200 Kw., 460 Volts D.C.—JENNINGS, West Walls, Newcastle-on-Tyne. 1701

WESTHOUGHTON.

For Sale outright, or on Yearly

Rental, VALUABLE FREEHOLD ENGINEERING WORKS, in bays approximately 130 yards in length, and covering some 15,000 square yards of concreted floor space, provided practically throughout with overhead cranes, electric power, either produced on site with present plant, or, alternatively, supply company's mains already fixed.

Some 6½ acres with connection to Railway Main Line. Good Offices. Water and Gas.

Further particulars, MANAGER, WESTHOUGHTON COAL & CANNEL CO., LTD., Westhoughton. F 382

For Sale.—One Second Hand

60 B.HP. "National" High Speed GAS ENGINE, two Flywheels, with tanks complete. In good running order. Electric Ignition.

One Second Hand 30 B.HP. "Crossley" High Speed GAS ENGINE in good order, with tanks. Type T.E. Electric Ignition.

One Second Hand 10 B.HP. "Crossley" GAS ENGINE. One Flywheel. In fair order.

One Second Hand STEAM ENGINE, 13 in. Bore, 26 in. stroke Cylinder with Flywheel. Complete. In good order. Suitable for 80 lbs. steam pressure.

The above can be seen at our Works at any time by appointment.

Apply:—
GIMSON & CO. (Leicester), Ltd.,
Vulcan Road,
Leicester. F 582

Alfred Herbert Ltd.,

'Phone: 860 (8 lines). COVENTRY, Wires: Lathes, Coventry.

Surplus Machines.

You are cordially invited to inspect the large stocks of NEW, RE-CONDITIONED and SECOND-HAND machines which we are offering at specially reduced prices from our Coventry Warehouses. The following is a selection:—

DRILLING MACHINES.

Alfred Herbert Two-Spindle B.B. Drill (one geared and one plain Spindle), with hand feed. (RE-CONDITIONED).

3 ft. 0 in. Wisconsin H.S. Sensitive Radial Drill, with gear box drive through F. & L. pulleys, swinging table and reverse for tapping. (NEW.)

3 ft. 0 in. American Tool Works Plain Radial Drill, with single pulley drive through gear box and swinging table. (SECOND-HAND.)

GEAR CUTTING MACHINES.

No. 65 Fellows Gear Shaper, complete with pump, countershaft, and spanner, but without guides. (SECOND-HAND.)

No. 4a Cincinnati Gear Cutter, cap. 48 in. dia. 12 in. depth, 10 module in steel. (RE-CONDITIONED.)

6 in. Gleason Bevel Gear Generators. (SECOND-HAND.)

LATHES (CENTRE).

6½ in. by 6 ft. 0 in. Crowthorn S.S. & Sc. Lathe, C.P. back geared, semi-quick change, 1½ in. hole through spindle, admits 3 ft. 0 in. between centres. (NEW.)

7½ in. by 7 ft. 0 in. Parkinson "Twink" S.S. & Sc. Lathe, all geared head, quick change with solid spindle, admits 3 ft. 0 in. between centres. (RE-CONDITIONED.)

9 in. by 8 ft. 0 in. Hendey S.S. & Sc. Lathes, C.P. back geared, quick change, 1½ in. hole through spindle, admits 4 ft. 3 in. between centres. (RE-CONDITIONED.)

MILLING MACHINES.

No. 0a Le Blond Plain Mills, C.P. drive, single back geared, cap. 18 in. by 6 in. by 15 in. (NEW.)

No. 2b Bilton Plain Mills, C.P. drive, single back geared, cap. 27 in. by 8 in. by 18 in. (NEW.)

No. 6 Alfred Herbert Universal Mill, C.P. drive, cap. 25 in. by 8 in. by 18 in., with standard equipment. (RE-CONDITIONED.)

PLANING MACHINES.

24 in. by 24 in. by 6 ft. 0 in. Bateman Planer with two heads on cross rail, S.S. & Sc. countershaft. (RE-CONDITIONED.)

108 in. by 108 in. by 20 ft. 0 in. Shanks Planer, with two swivel heads, complete with overhead staging, Vickers motor (including switch and rheostat, resisting boxes, start and stop buttons and all internal wiring). (SECOND-HAND.)

R18 Koping Openside Planer with F. & L. Pulley, double friction countershaft, two tables, tool box and spanners. (NEW.)

MISCELLANEOUS.

4 in. Hulbert Rogers Cutting-off Machine, rear end chuck, pump tank and fittings. (RE-CONDITIONED.)

No. 3 Photostat Copying Machine, with book-holder and copy board, complete with lighting equipment suitable for 200 volts, A.C., 50 periods. (RE-CONDITIONED.)

No. 11 Garvin Screw-Head Shaving Lathe, straight bed, fitted with cross slide feed with two tool posts, oil pump fittings and Countershaft, auto chuck, cap. 1¼ in. (NEW.)

SURPLUS LIST No. 11 GIVES ADDITIONAL DETAILS AND PRICES. F 563

350 HP. Steam Engine.

Vertical, compound, central valve type, by Willans & Robinson. 150 lbs. working pressure. Heavy bed and 4 ft. flywheel.—WELDING'S, 77, Vauxhall Road, Liverpool. F 556

Engineers and Plumbers

Brassfoundry. Modern fully equipped FACTORY FOR SALE as going concern. Birmingham district. Large orders on books. Full particulars to principals or solicitors only.—Address, F 557, Offices of ENGINEERING.

For Sale.—Fielding Gas

Engine, New, 42 B.HP. Flywheel, self-starter, usual accessories, spares, suitable town or suction gas. Low price to clear. Also suitable suction gas plant, if desired.—R. SHONE & CO., Cunard Building, Liverpool. F 580

Unique Opportunity. Left

on hand in satisfaction of debt. FOR SALE: Electric Washing Machines and Ironers, some finished, others partly completed, with large stock of casting, parts, motors and other accessories, including patterns.—Address, F 574, Offices of ENGINEERING.

PATENTS AND DESIGNS ACTS, 1907 AND 1919.

The Proprietors of British

Patent No. 106520 are PREPARED to SELL the PATENT or to license British Manufacturers to work thereunder. It relates to Gear-cutting Machines for cutting gears or pinions of the curved herring bone type.—Address, B. W. & T., 112, Hatton Garden, London, E.C. 1. F 561

Overhead Electric Two-ton

RUNWAY (New) FOR SALE, Herbert Morris, cage operated, packed as just delivered, 280 feet with one bend, approximate height 28 feet. With or without 3 phase Motors 220 volts. Magnificent plant. Will sell at 25 per cent sacrifice.—Apply, C. L. STIFF & CO., LTD., Slag Breakers, East Ardsley, near Wakefield F 446

Steel Screwed and Socketed

PIPING.
FOR IMMEDIATE DELIVERY.

6 in.	-	30,000 feet.
8 in.	-	9,960 ,,
10 in.	-	18,000 ,,
12 in.	-	14,000 ,,

Full particulars from
THOS. W. WARD LTD.,
ALBION WORKS, SHEFFIELD.
London Works, Silvertown, E.16. F 21

The Proprietors of Letters

Patent Nos. 16736/1913 relating to
THREADING DIES,
10830/1915 relating to
TURRET LATHES,
and 101599 relating to
TURNING LATHES,
DESIRE to DISPOSE of their PATENTS or to grant licences to interested parties on reasonable terms for the purpose of exploiting the same and ensuring their full commercial development and practical working in this country.

Enquiries to be addressed to CRUIKSHANK & FAIRWEATHER, 65/66, Chancery Lane, London, W.C. 2. F 499

Govan Engine Works,

GLASGOW.

FOR SALE
IN WHOLE OR PLOTS.

GROUND extending to 42,672 square yards, and BUILDINGS thereon of Engine and Boiler Shops (lately belonging to Messrs. DUNSMUIR & JACKSON, Ltd.), equipped with Overhead Travelling Cranes up to 60 tons.

For particulars apply—
WEARING & MARTIN,
Writers,
180, Hope Street, Glasgow.

The H. A. Dudgeon Machine Co.

Head Office & Showroom: Friars Road, Coventry.
'Phone: 2129. Telegrams: "Dudgeon, Coventry."
London Office:
11, Queen Victoria Street, London, E.C.4.
'Phone: City 1256. 'Grams: "Witlatool, Cannon, London."

WHY BUY NEW MACHINES?

We can supply good Second-hand Machines 25% to 75% below makers prices.

SEND FOR LIST.

HERBERT No. 9 COMBINATION LATHES.
*HERBERT No. 4 CAPSTANS.
LANDIS 6 in. by 18 in. SELF-CONTAINED GRINDER.
*HEALD No. 60 CYLINDER GRINDER.
HEALD No. 70 INTERNAL GRINDER.
*VERTICAL BORING AND TURNING MILLS.
J. & S. FOUR-SPINDLE B.B. DRILL.
CLEVELAND AUTOMATIC, 2½ in. CAPACITY.

THIS WEEK'S BARGAIN.
GARDNER 16 in. CRANK PIN TURNING LATHE. First class condition, £200.

* In our Coventry Stock. F 261

For Sale or to Feu in Whole

OR PLOTS.

68 ACRES OF GROUND AND BUILDINGS, suitable for works, at Inchinnan, on the main road between Glasgow and Greenock.

One building, length 260 ft. by 150 ft., height 48 ft. to eaves, structure of brick and steel, lit from roof, contains approximately 37,500 sq. ft. floor space.

One building, in several bays, 330 ft. long at the longest part 258 ft. broad, height one part 24 ft. 6 in. to eaves, other part 16 ft. to eaves, structure of brick and steel, lit from sides and roofs, granolithic floors, mechanically heated, contains approximately 83,000 sq. ft. floor space.

One building 320 ft. long by 160 ft. broad, height, 16 ft. 9 in. to eaves, with small annex 50 ft. by 30 ft. structure of brick and steel, granolithic floors, lit from sides and roof, mechanically heated, approximately 53,000 sq. ft. floor space.

Electric power is laid into each of these buildings from the Clyde Valley Power Station, also water supply.

For further particulars apply to:—
WEARING & MARTIN, Writers, 180, Hope Street, Glasgow.

For Sale.

ENGINE SHOP MACHINE TOOLS.

Heavy Side Planer, horizontal travel 15 ft., vertical travel 11 ft. 2 ins. Heavy Setting Table 16 ft. by 7 ft. 3 in. Direct Motor Driven. By Shanks & Co.

Double-headed Horizontal Boring and Tapping Machine, each head fitted with 4 in. spindle, 3 ft. 2 in. travel. Bed 30 ft. long by 4 ft. 6 in. broad. Heads operatable over 24 ft. in breadth and 11 ft. in height. Heavy Setting Table 30 ft. long by 6 ft. broad. Belt driven. By Loudon Bros., Johnstone.

Heavy Duty Lathe 3 ft. 9½ in. centre. Length of Bed 19 ft., takes between centres 8 ft. 6 in. 10 ft. Face Plate. Two Tool Holders on common saddle Compound Slide. Belt driven. By Shanks & Co., Johnstone.

Heavy Screwcutting and Surfacing Gap Bed Lathe, 1 ft. 11½ in. centre. Bed 36 ft. long with four Tool Holders each on compound slide rests. Takes between centres 25 ft. Belt driven. By G. & A. Harvey, Glasgow.

Heavy Gear Cutting Machine, revolving table 7 ft. 9 in. diameter, Milling Head, adjustable to any angle, spare table and frame smaller diameter with change Speed Gear Boxes to each motion. Bridge Head and Standard with spare parts for various operations. Motor driven. Attached to machine is Weighing Machine, relieves up to 20 ton tare. By Wm. Muir & Co., Manchester.

Double-headed Facing and Boring Mill. Horizontal, each head is balanced and has worm-driven, 4-jaw chuck, 2 ft. 6 in. diameter, and traverses along bed 5 ft. 6 in. Head rises and falls 2 ft. 6 in. Each head is independently driven by 25 b.hp. Motor. Between heads there is a heavy planed and slotted Fixing Table, 4 ft. long by 8 ft. broad, supporting 4 Housings with 15 ft diameter Shafting Bearings or Stays, adjustable to same variations in height as heads. Motor driven. By Shanks & Co., Johnstone.

Heavy Side Planer, horizontal travel 11 ft. 6 in., vertical travel 10 in., with Setting Table 12 ft. by 14 ft. Belt driven. By Loudon Bros., Johnstone.

Apollo Combination Turret Lathe 12 in. centres, all-gear head, square Turret for facing work, and Hexagon Turret for boring, mounted on slide 4 ft. long, hollow spindle admits 4½ in. diameter, overall length 11 ft. 6 in. Makers, Pollock & MacNab.

BOILER SHOP PLANT.

Four-Headed Boiler Shell Boring Machine, Heads set and travel, Shear Bed 60 ft. long by 4 ft. 6½ in. broad. Each Head rises and falls on own column, 7 ft., and operated by 10 h.p. Motor. Spindles 4 in. diameter, 2 ft. travel. Each pair of heads have heavy C.I. Foundation Plane or Boiler Carriage in front, 19 ft. by 8 ft. Grooved for adjustment of 2 pairs of Worm-Driven Wheel Trunnions on roller bearings, on which boiler revolves for boring operation. Trunnions operated by 10 b.hp. Motor. By The Low Moor Co., Ltd., Bradford.

Vertical Hydraulic Riveter, 13 ft. Gap, with Valves and Control Gear, up to 160 tons pressure on rivet casting steel throughout. By Hugh Smith and Sons, Glasgow.

Heavy Plate Bending Machine, takes plate up to 13 ft. in breadth, top and bottom entablatures steel. Setting Column Steel, operated by Link Gearing or Fulcrum impelled hydraulic cylinder. Two Drawback Hydraulic Cylinders and Hydraulic Cylinder Operating Vertical Roll 13 ft. high by 2 ft. 6 in. diameter. Complete with gearing. By Hugh Smith & Son, Glasgow.

Double-headed Heavy Drilling Machine, 3 in. balanced spindle heads operated over 10 ft. 6 in., in breadth from mutual, wall type. Entablature 33 ft. long, and supported on each head independent. Each head operated by Motor. By G. & A. Harvey, Ltd., Glasgow. 3 Heavy C.I. Columns with 3 rolled steel joists grouted as Setting Bed.

Vertical Manhole Cutting Machine, balanced spindle setting table 5 ft. 6 in. by 5 ft., on compound rests. Driven direct by Motor. By G. & A. Harvey, Ltd., Glasgow.

1½ in. Double-ended Punching and Shearing Machine, with Angle Cutter Cam and lever motion. Shearing Gap 2 ft. 6 in., Punch Gap 3 ft., with 2 Swing Cranes attached, 13 ft. radius, each, having set of 2-ton "Thomson" Lifting Blocks attached, direct driven by Motor and Starter.

Hydraulic Flanging Press with Vertical Ram 10 in diameter, for flattening process, Vertical Ram 10 in. diameter, for flanging process, and Horizontal Ram 7 in. diameter, flanging process, with drawback cylinders to each motion, complete with Valves and Piping. By Twedella, Gloucester.

Heavy Double-ended Punching and Shearing Machine, geared motion with angle cutter. Punch Gap 3 ft., Shear Gap 2 ft. 6 in., by Smith Bros., Glasgow, with two Swing Cranes attached, each 18 ft. radius and each having set of 3-ton Blocks attached, direct driven by Motor.

Heavy Hydraulic Flanging Press, with Vertical Ram 12 in. diameter, for surface flattening, and holding Vertical Ram 12 in. diameter for flanging and horizontal, &c.—All three motions fitted with drawback cylinder and hydraulic valves and piping Hydraulic Crane Mounting on top, 24 ft. radius. By H. Smith & Sons, Glasgow.

For further particulars apply to
THE GOVAN ENGINE WORKS, LIMITED,
180, Hope Street, GLASGOW.

For Immediate Disposa

120,000 gallons per hour Horizontal T... Expansion Surface Condensing Worthing... PUMPING ENGINE, with Duplex Double Act... Well Pumps, and Duplex Double Acting High ... Pumps, new erected, as purchasing firm do ... require delivery for 12 months. Can be inspe... at Worthington Simpsons Works, Newark.—Ad... F 345, Offices of ENGINEERING.

Big Bargain.—16 Kw. Pet...

Electric GENERATING SET, compo... Dorman Four Cylinder Vertical Engine, 3½ B.H... 1000 Revs., Fan-cooled Radiator, Fuel and W... Tank, direct connected to 16 Kw. Semi-encl... Dynamo. Fourpole interpole, Carbon Brushes, ... olling bearings. Dixie Magneto. Price £10... nearest.—MIDLANDS BELT, Huntingdon St... Nottingham. F...

Electric Generating Plant f...

SALE.

Direct Current.

Two	26 Kw.	105 Volts.	"Howden-B.E.E."
Two	52 ,,	,, ,,	"Brotherhood - Laurence Scott."
Two	100 ,,	440/560 ,,	Gerrett Semi-Portable.
One	120 ,,	110 ,,	"Belliss-Siemens."
One	150 ,,	220 ,,	"Howden-Lane, Dynam...
Two	200 ,,	,, ,,	"W. H. ALLEN."
Two	200 ,,	,, ,,	"Belliss-Siemens."
One	240 ,,	440/500 ,,	"Belliss-Phœnix Dynam...
One	375 ,,	250 ,,	"Allen-Westinghouse."
One	400 ,,	240 ,,	"Howden-Siemens."
One	500 ,,	230 ,,	"Howden-B.T.H."
One	500 ,,	230 ,,	"Belliss-B.T.H."
One	500 ,,	500 ,,	Metropolitan Vickers Tur...
One	600 ,,	500 ,,	"Belliss-Mather & Platt."
One	750 ,,	220 ,,	"Parsons-Crompton" Geared Turbo.
One	1250 ,,	250 ,,	"Belliss" Turbo.

Alternating Current, 3-Phase, 50 Periods.

One	400 Kw.	550/550 Volts.	"Howden-G.E.C."
One	750 ,,	,, ,,	"Metropolitan Vickers."
One	850 ,,	,, ,,	"Fraser & Chalmers."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	1000 ,,	3300 ,,	"B.T.H."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	2000 ,,	500/550 ,,	,, ,,
One	3000 ,,	6600 ,,	"B.T.H." ,,

All above are modern, and condensing plant ... available in nearly all cases.

We can also offer several Suction Gas and Die... Sets, Babcock Boilers up to 30,000 lbs. per hour, a... a very large number of motors, generators, Mot... generators, rotary converters, etc.

Enquiries Invited.

THE PHŒNIX ELECTRICAL COMPANY, Ltd.,
17, OSWALD STREET, GLASGOW.

TANKS

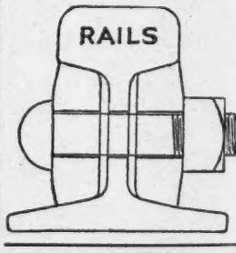
GALVANISING & CONSTRUCTIONAL IRONWORK.
JOSEPH ASH AND SON, LIMITED,
Rea Street South, BIRMINGHAM.

MICHELL BEARINGS, LD.,

ENGINEERS and MANUFACTURERS OF
Michell Thrust & Journal Bearings.
London Office:
3, Central Buildings, Westminster.
See large Advertisement, page 90, Aug. 1.

THOS. W. WARD LTD.,

Albion Works,
SHEFFIELD.



RAILS

In 52 sections... 12lbs. to ... 112lbs. Per Yard.

All Accessories Platelayers Tools.

Do not buy Until You KNOW OUR PRICES.

DIALS

STEAM GAUGE DIALS, ...
INDICATING MACHINE DIALS &c.

JAMES COOKE & SON,
8 & 9, WRENTHAM ST., BIRMINGHAM.
Specialists in Dials. Est. 75 Years.
'Phone: Mid. 1611. 'Grams: "Horology," Birmingham

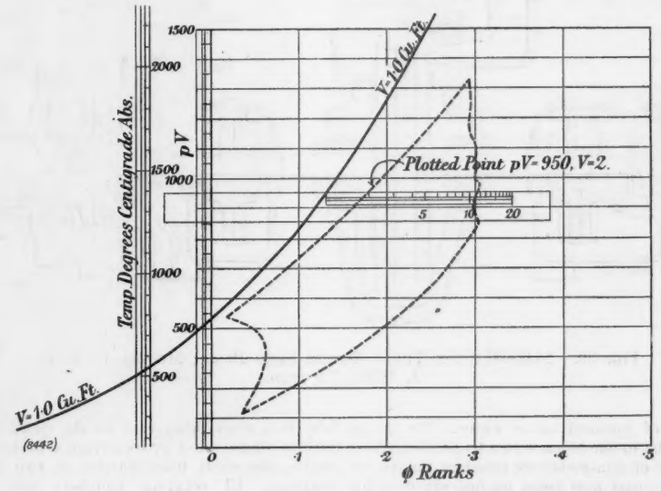
A MODIFIED TEMPERATURE-ENTROPY DIAGRAM FOR A GASEOUS WORKING SUBSTANCE.

By Professor G. E. SCHOLES, Liverpool University.

THE customary form of the temperature entropy chart for one pound of a gaseous working substance involves the construction of several constant-pressure and constant-volume lines, and the number of these lines is considerable. In locating a point on the Tϕ chart, the knowledge required is that of the pressure of the gas and its volume per pound. The point on the Tϕ chart is then obtained by determining the point of intersection of the corresponding constant pressure and constant volume lines: *e.g.*, if the pressure is 300 lb. per square inch absolute and the volume 2 cub. ft., the corresponding point on the Tϕ chart would be at the intersection of the constant pressure line of 300 lb. per square inch absolute and the constant volume line of 2 cub. ft. In practice, the accurate determination of the point of intersection of these lines is not easy, for two reasons:—

1. The value of the pressure necessitates interpolation.

2. The constant pressure and constant volume lines approach each other at a slight angle and the position of the point of intersection is a matter of doubt.



Since, in order to locate a point on the Tϕ chart, it is necessary to have simultaneous ordinate and abscissa values, *i.e.*, corresponding values of T and ϕ, the author investigated whether the information available, viz., that of the pressure and volume per pound of the gas would be adequate to determine these values. If the ordinate value be known, then the height of the plotted point on the chart is fixed, and it would only remain to fix its abscissa value. If, further, the volume or pressure is known, then the abscissa or ϕ value can be found by simple logarithmic interpolation from any one of the constant volume or constant pressure lines, respectively.

In the equation PV = RT, the product PV is proportional to T, and hence a corresponding PV scale may be plotted in addition to the T scale. Generally, pressures are measured in lb. per square inch absolute, and volumes in cubic feet.

Then if R = 99 ft.-lb., the Centigrade scale of thermometry being used—

PV = 99T, where P = pressure in lb. per square ft. absolute

or 144 pV = 99T where p = pressure in lb. per square in. absolute,

V = volume per lb. in cub. ft.

and T = absolute temperature deg. C.

$$\text{or } pV = \frac{99}{144}\,T$$

$$= \frac{11}{16}\,T.$$

From this relation the corresponding scales to be used for the T and pV scales may be determined, and the corresponding value of the pV product for any value of T.

If, for example, the T scale is such that 1 in. = 100 deg. C., then the corresponding pV scale is such that

$$1 \text{ in.} = \frac{11}{16} \times 100 = 68{\cdot}75\ pV \text{ units.}$$

Again, for T = 400

$$pV = \frac{11}{16} \times 400 = 275.$$

This information enables the pV scale to be constructed and placed correctly relatively to the T scale.

Since the horizontal position of the point may be fixed from a knowledge of the pressure or volume, it is necessary to decide which of these functions should be used. The volumes per lb. of gaseous working substances as used in internal-combustion engines, lie between 1·0 and 20 cub. ft., and the author uses on the modified Tϕ chart a constant volume line of 1·0 cub. ft. This is the only curve on the chart, and with this is used a simple logarithmic volume scale, shown below. In order to determine the position of a point on the Tϕ chart, it is now necessary to know the pV product and the value of V. The pV product fixes the height of the point, and the V value its position with reference to the 1·0 cub. ft. constant volume line, using the logarithmic scale to locate the point.

Construction of the Chart.—If the working substance be assumed to have specific heats which are functions of the absolute temperature, and if

$K_p = a + sT - uT^2$

$K_v = b + sT - uT^2$

$PV = J(K_p - K_v)T = J(a - b)T = RT$

Then

$$dH = K_v\,dT + A\,P\,dV$$

$$d\phi = K_v\frac{dT}{T} + \frac{A\,P}{T}\,dV$$

$$= K_v\frac{dT}{T} + A\,R\,\frac{dV}{V}, \quad \text{where } A = \frac{1}{J}$$

$$= (b + sT - uT^2)\frac{dT}{T} + AR\frac{dV}{V}, \text{ and integrating}$$

$$\phi = b\log_e T + sT - \frac{uT^2}{2} + AR\log_e V + \text{constant}$$

$$\phi_2 - \phi_1 = b\log_e\frac{T_2}{T_1} + s(T_2 - T_1) - \frac{u}{2}(T_2^2 - T_1^2) + A\,R\log_e\frac{V_2}{V_1} \quad . \quad (1)$$

For a constant volume line $V_2 = V_1$ and

$$\phi_2 - \phi_1 = b\log_e\frac{T_2}{T_1} + s(T_2 - T_1) - \frac{u}{2}(T_2^2 - T_1^2) \quad (2)$$

For any assumed temperatures T_2 and T_1, $\phi_2 - \phi_1$ is the same, no matter what constant volume line is considered; *i.e.*, all constant volume lines are identical in shape.

If the temperature is constant, *i.e.*, $T_2 = T_1$, then

$$\phi_2 - \phi_1 = A\,R\log_e\frac{V_2}{V_1} \quad . \quad . \quad (3)$$

and, at the same temperature, the change in entropy for a volume change from V_1 to V_2 is $A\,R\log_e\frac{V_2}{V_1}$, *e.g.*, if $V_1 = 1$, and $V_2 = 7$, the increased entropy due to this increased volume at any constant temperature is $A\,R\log_e 7$. This value thus gives the horizontal displacement on the Tϕ chart of the point V = 7 from the constant volume line of 1·0 cub. ft. The logarithmic volume scale is constructed and marked such that the distance between the zero of the scale and the particular volume marked V, is $A\,R\log_e V$ units of entropy.

To calculate the entropy values for V = 1·0 cub. ft., some condition of the gas has to be chosen for which the entropy is assumed to be zero. The author has taken the values of the specific heats due to Stodola, as given in the paper "An Energy Diagram for Gas Mixture and Some of its Uses," by Wm. Alexander, Proceedings of the Institution of Mechanical Engineers, May, 1917, and has assumed that the entropy of the gaseous working mixture is zero at atmospheric pressure and at a temperature of 300 deg. C. absolute. The values of K_p and K_v so given are

$K_p = 0{\cdot}2377 + 0{\cdot}000062\,T - 0{\cdot}725 \times 10^{-8}\,T^2$

$K_v = 0{\cdot}167 + 0{\cdot}000062\,T - 0{\cdot}725 \times 10^{-8}\,T^2$

For zero entropy p = 14·7 lb. per square inch absolute, T = 300 deg. C. absolute and

$$V = \frac{J(0{\cdot}2377 - 0{\cdot}167)T}{14{\cdot}7 \times 144}$$

$$= \frac{99 \times 300}{14{\cdot}7 \times 144}$$

$$= 14{\cdot}02 \text{ cub. ft.}$$

At any given temperature, therefore, the difference of entropy for V = 14·02 and V = 1·0 will be

$$A\,R\log_e\frac{14{\cdot}02}{1} = 0{\cdot}187 \text{ Ranks.}$$

If in equation (2) ϕ_1 be put zero for T_1 = 300, then the values of the entropy of the gas for the constant volume 14·02 cub. ft. can be calculated for any temperature. Equation (2) then reduces to

$$\phi_{(V=14{\cdot}02)} = -0{\cdot}971 + b\log_e T + sT - \frac{uT^2}{2} \quad (4)$$

and since $\phi_{(V=1)}$ is 0·187 Ranks less than $\phi_{(V=14{\cdot}02)}$ we have

$$\phi_{(V=1)} = b\log_e T + sT - \frac{uT^2}{2} - 1{\cdot}158 \quad . \quad (5)$$

From this equation (5) corresponding values of T and ϕ may be obtained and are here calculated.

T (deg. C. abs.)	ϕ (V = 1·0 cub. ft.)
2,000	0·2219
1,800	0·1942
1,600	0·1646
1,400	0·1331
1,200	0·0958
1,000	0·0546
800	0·0062
600	− 0·0532
400	− 0·1326
200	− 0·2603

The T ϕ chart may now be plotted to any suitable scale, as in the diagram.

Transference of Indicator Diagram to T ϕ Chart.—For a detailed method of the preparation of the indicator diagram prior to the transference to the T ϕ chart and for the information obtainable from the transferred diagram, the reader is referred to William Alexander's paper previously mentioned. By this method, the corresponding pressures in pounds per square inch absolute and volumes in cubic feet per pound, are determined, the volumes being expressed in whole numbers. From this information the product pV is obtained for each point. From the pV and V values the diagram is quickly and accurately plotted, the time saved being appreciable compared with previous methods.

The author claims for the modified chart a greater simplicity in construction and use, combined with a considerable saving in time. In teaching it has the advantage that each student constructs his own chart, and benefits by the increased knowledge so obtained as compared with the use of a chart which he has not constructed. It may be pointed out that the single constant volume line used may be done away with by the use of an additional entropy scale on the logarithmic volume scale, but it is not thought desirable to suggest that this should be done.

Experiments carried out to predict the thermal

PUMPING MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

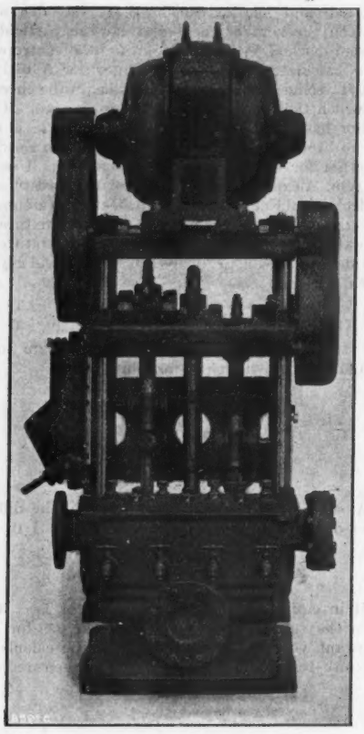


Fig. 38. Motor-Driven Two-Throw Double-Acting Pump; Messrs. G. and J. Weir, Limited.

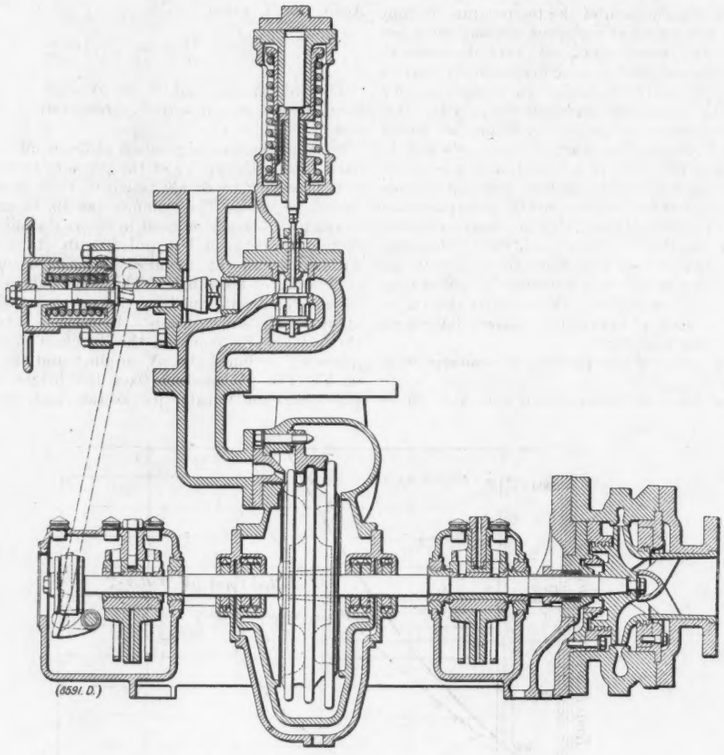


Fig. 39. 20,000-Gallon Turbo Boiler-Feed Pump; Messrs. G. and J. Weir, Limited.

efficiency of an internal-combustion engine from an indicator card by calculating the thermal efficiency given by the transferred indicator diagram on the T ϕ chart have proved satisfactory, the agreement between the actual test and the predicted thermal efficiencies being very close.

BRITISH EMPIRE EXHIBITION: PUMPS AND PUMPING MACHINERY.—III.

The exhibit at the stand of Messrs. G. & J. Weir, Limited, of Cathcart, Glasgow, embraces a wide range of pumps, condensing plant and compressors, the variety being increased by the presence at the stand of several examples of pumping plant constructed by Messrs. Drysdale and Co., Limited.

The examples shown by Messrs. Weir include a large number of their well-known pattern of direct acting boiler-feed pump, with which most engineers are now familiar. Examples of pumps for oil fuel transfer, oil fuel pressure, and for water service are also exhibited, as well as the specially compact type of feed pump which Messrs. Weir have developed in connection with feed water heating on locomotives. This pump and the multiflow-type of heater, in conjunction with which it is used, were described and illustrated in Engineering, vol. cxii, page 150.

Another class of reciprocating pump shown by the firm covers motor-driven two-throw double-acting pumps, of which an example is illustrated in the accompanying Fig. 38. A 5-in. by 6-in. pump is shown at the exhibition, the motor being fixed on the top of the pump entablature, making a very compact design, occupying a minimum of floor space. In addition to its advantages from this point of view, which are especially valuable in marine work, the motor in this position is well out of the way of splashed oil or water. The pump barrels are cast in one block with a large rectangular base. Liners of gun-metal are fitted in pumps for water service, cast iron being exclusively used for oil. The valve box is cast separate and bolted to the pump body casting. The main entablature is carried directly over the pump barrels by very stout steel columns, the whole forming a very rigid structure. The crosshead guide brackets are securely bolted to the columns. The connecting rods and crossheads are of special malleable cast iron. The crankshafts, of open hearth mild steel, have cranks set at 90 deg., and run in gun-metal bearings, fitted with automatic grease cups. The countershaft entablature is arranged directly over the main entablature and carries the intermediate shaft with double reduction gearing. It is surmounted by the motor. The gearing is of the straight-spur type, with the first reduction pinion on the motor shaft of raw hide. The spur wheels are of cast iron, the countershaft pinion being of steel. A special form of tooth has been adopted for these gears, giving a very silent running train. The tooth loads are low and the life, therefore, long. The motor controller is fitted on the left side of the columns, all electric cables between the controller and motor being enclosed in ducts. Where height is a consideration of moment with the larger sizes of pumps of this type, the motor is set directly over the valve box, bringing the countershaft and crankshaft to the same level. Another variation is the provision of worm reduction gear.

Fig. 39 illustrates Messrs. Weir's popular turbo boiler-feed pump, which also forms part of the firm's exhibit. This pump, of the single stage centrifugal type, is driven by an impulse turbine, having one pressure and several velocity stages, and is designed for the use of highly superheated steam. The general arrangement will be clear from the section, the shrouded impeller with labyrinth rings being seen at the right, while the turbine surmounted by its governor is shown in the centre, the shaft being carried in two ring-oiled bearings. All rotating members are carefully balanced, and are readily accessible for examination and overhaul. The turbine casing and bearings are split horizontally, the lower portions forming part of the general bed of the unit.

This bed is extended at one end, as shown, to form a flange, to which the pump casing is fixed. The impeller is thus carried on an overhung length of the turbine shaft, an arrangement characterised by compactness and ensuring good alignment. The turbine casing being exposed only to exhaust steam pressures and temperatures, is made of close grained cast-iron. The nozzle-box and the throttle are of cast steel. The shaft is of nickel chrome steel, fitted with a non-corrodible sleeve where it passes through the pump gland. The turbine stuffing boxes are provided with carbon packing, which can be removed without lifting the top half of the casing.

The admission of steam to the turbine is primarily regulated by a stop valve of the screw-down disc type. By means of a spring-loaded piston and dashpot, arranged on the valve spindle and controlled by a trip gear working in conjunction with an emergency governor in the end bearing housing, this valve is used as an emergency or safety stop valve as well. The emergency governor mounted on the end of the shaft consists of an unbalanced ring kept in a concentric position by means of a spring. When a predetermined speed is attained, the resistance of the spring is overcome, and the ring takes up an eccentric position. It then, in rotating, strikes a trigger, which immediately releases a lever holding back the spring-loaded piston of the stop valve. The valve, thus freed, closes instantaneously under the action of the spring. The nozzle box is designed so that

PUMPING MACHINERY; BRITISH EMPIRE EXHIBITION.

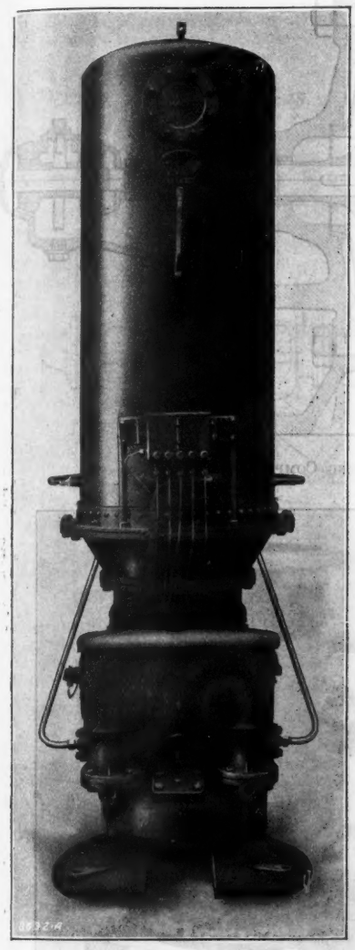


FIG. 40. EMERGENCY BILGE PUMP: MESSRS. DRYSDALE AND CO., LIMITED.

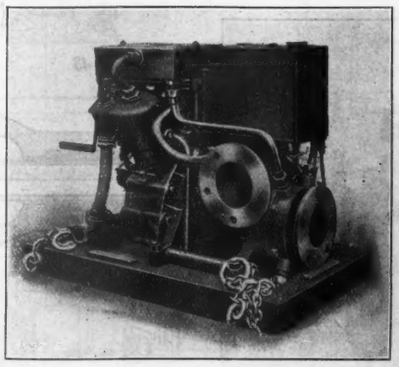


FIG. 41. 4-INCH SALVAGE PUMPING SET; MESSRS. DRYSDALE AND CO., LIMITED.

when the pump is lightly loaded no auxiliary nozzles are needed, but at full load and overload, one or more auxiliary valves are opened as required.

The pump casing is of bronze, with labyrinth rings of a special bronze alloy, the impeller being of Monel metal, which has proved itself especially suitable to withstand the erosive action of water at the high velocities required to generate 400 lb. pressure in one stage. The impeller is in automatic hydraulic balance, thrust bearings thus being obviated. The thrust collars shown in the inner bearing are for location purposes during starting and stopping and do not carry end load.

The pump discharge pressure is normally controlled by a governor which maintains a constant pressure at the pump discharge, regardless of ordinary fluctuations in the steam pressure or in the quantity of water discharged. The governor performing this function is mounted above the throttle valve casing, and comprises a spring-loaded piston operated by the pump, and directly connected to a balanced throttle valve controlling the supply of steam to the turbine according to the load on the pump. The discharge pressure may be varied by adjusting the spring pressure. This is accomplished by turning the hexagonal head of the spring adjuster immediately below the spring case. The set is self-regulating for all ordinary changes in either water or steam conditions. When the latter are decidedly adverse, auxiliary nozzles may be brought into play by means of auxiliary valves in the nozzle-box and the supply of steam is augmented. The set shown at the firm's stand has a capacity of 20,000 gallons per hour. Sets are made up to 50,000 gallons per hour capacity.

The "Paragon" air pump of Messrs. Weir, also to be seen at Wembley, is a new design of wet pump having the advantage of being more compact for the same weight than former models. This is a twin pump combined with an ejector augmentor. The model shown is steam driven, the two pumps being worked by a single overhead steam cylinder and rocker gear. The pump can be arranged for electric drive. The two pump barrels are fitted to a common base and top. The pump crossheads and guides are arranged centrally back to back. The steam cylinder is carried directly above one pump cylinder on steel columns. The condensate is led from the main condenser to the pump base and is handled by both barrels. The augmentor is a vertical inverted steam ejector mounted in the centre of a horizontal tubular condenser. The latter is supplied with the pump condensate discharge. The air and non-condensible gases are withdrawn from the main condenser, and discharged, by the ejector into the augmentor condenser, where their heat is given up to the water passing to the hot well, and the ejector steam is condensed. The condenser water makes two passes through the condenser, while the ejector discharge is also forced to take a long path among the tubes, by deflectors. A large tee-piece couples the augmentor condenser with a valve box containing a Kinghorn type non-return valve on each barrel, the discharge from the augmentor entering the pump cylinders alternately. The ejector is of the multi-nozzle type, designed to operate with a steam pressure of 100 lb. per square inch. The set is specially intended for use with steam turbine installations with high vacuum.

We mentioned above that Messrs. Drysdale and Co., Limited, have an exhibit which is combined with that of Messrs. G. and J. Weir. Messrs. Drysdale's exhibit includes centrifugal pumps of several forms and sizes, and several special types of pump including vertical spindle centrifugals, a vertical centrifugal two-stage extraction pump, a vertical bilge pump, and a small salvage set. The examples shown also include a 36-in. twin parallel dock pump, a dock leakage pump, six-stage high lift centrifugal, an 8 in. sand dredging pump, and others. The vertical spindle pump has a divided casing, split on the vertical centre line, the front half being detachable, while the back half is embodied in the casting forming the base and column, above which is mounted the vertical spindle motor direct connected with the pump. A hand hole is provided in the front half of the cover. The pump is designed primarily for work on board ship, but is not recommended for purposes requiring suction lift. The impeller is shrouded on one side only, the thrust being in an upward direction, reducing the load taken by the thrust bearing. The thrust bearing is situated at the top of the motor. It is of the double thrust-ball type. The bottom motor bearing is also of the ball type. The shunt-wound motor is completely enclosed in a drip proof casing.

The firm's "S.O.S." emergency bilge pump is illustrated in Fig. 40 on this page. This is of the submersible type and a development of Messrs. Drysdale's Centrex pump, of which a 4-in. example is also shown at the exhibition. In the Centrex pump any air is separated from the water and handled separately. The vertical spindle centrifugal pump in the emergency bilge pump is placed in the base of the bottom casting, which, as in the case of the upright centrifugal, combines a large circular foot with a short open-fronted column, above which the direct-coupled motor is mounted. The column further embodies, at the back, suction and discharge passages, and an air-separating chamber. The motor is housed in a welded-steel bell, tested to withstand a pressure equivalent to 70 ft. head. A hand hole is fitted in the upper part, so that the commutator and brushes of the motor may be attended to. The pump is of the single-impeller type, shrouded on one side. The thrust is upward. The casing is split in a vertical plane and the impeller and spindle can be removed after taking off the front portion, without disturbing pipe joints. For priming and drawing off air which may come through the suction two small high-speed reciprocating air pumps are arranged, housed in front of the column. These are driven by worm gear from the main spindle. If air is present in the separating chamber at the back of the column it is drawn off by the pumps through pipes leading from a float valve chamber. If no air is present the separating chamber will be full of water and the float valve closes the communication to the air pumps. The air pumps have no suction valves, the pistons simply over-running ports. The discharge valves are of the metallic disc type. By withdrawing four bolts the air-pump gear can be removed. When working unsubmerged fresh air is drawn through openings into the bell and passed through the motor by a fan mounted on the armature. The pump can run submerged to such a depth that if the compartment in which it is mounted is completely filled with water the motor will not be flooded. The design is approved by the Board of Trade as satisfying the Regulations for Emergency Bilge Pumps. This pump is made in sizes ranging from a delivery of 50 tons to 200 tons of water per hour.

Messrs. Drysdale's "Pervac" pump is an electrically-driven centrifugal on somewhat similar lines to the foregoing, *i.e.*, the pump is arranged with its spindle vertical and one-half of the casing is integral with the column, which has a foot below and a flange to which the motor is fixed, above. This pump is a high-vacuum extraction pump for condensate. It is of the two-stage type, the lower impeller being designed for securing the best vacuum and the upper for dealing with head, and capable of producing a discharge at a pressure up to 20 lb. per square inch. The suction connection from the condenser joins the pump at the lowest possible point, close to the base, the condensate being delivered to a chamber at the back of the column, provided with an air trap. The latter is connected by an air vent to the condenser. Air separating out of the condensate at the eye of the first impeller is led to the trap, and does not pass through the pump. The suctions of the two impellers are opposed. Above the second stage is a pressure-sealing chamber, into which the discharge passes before leaving by the discharge connection. The spindle has only one gland, *i.e.*, that situated above the sealing chamber under pressure, so that no air leakage through the gland can occur. A bearing is provided between the two impellers and an external bearing between the gland and motor. As in the previous models, the front half of the casing can be removed without breaking pipe joints. The motor is fitted with an adjustable thrust bearing, under a canopy or cover, which protects the upper end of the motor from drips, &c. All these models of vertical-spindle pumps have the advantage of occupying a minimum of floor space, while the alignment of pump and motor is unaffected by any bolting-down strains that may be set up.

PUMPING MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

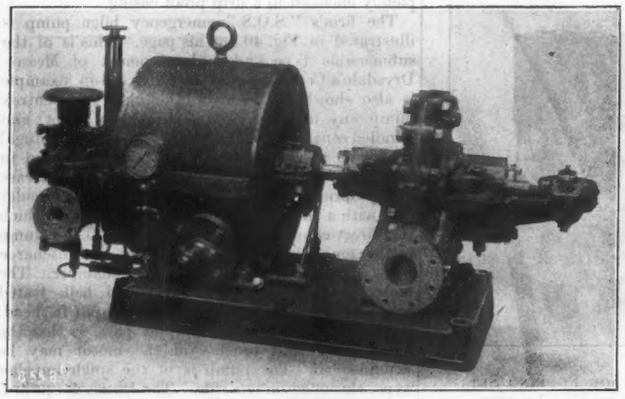


Fig. 42.

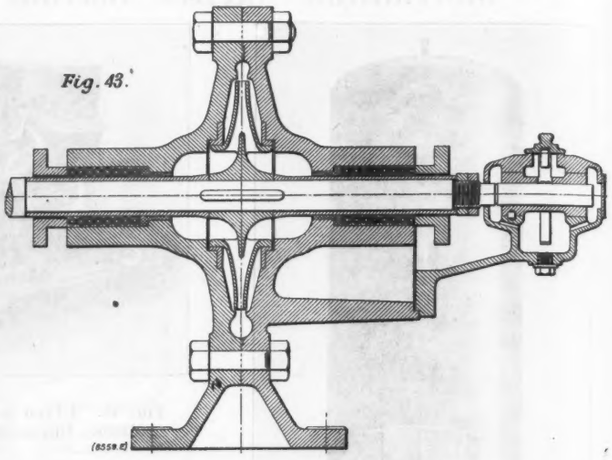


Fig. 43.

Figs. 42 and 43. Steam Turbine Boiler-Feed Pump; Messrs. Gwynnes Engineering Company, Limited.

We can only refer to one other of Messrs. Drysdale's exhibits, namely, a 4 in. salvage pumping set, which we illustrate in Fig. 41 on page 217. This set comprises a two-cylinder V-type petrol engine and direct-coupled centrifugal pump mounted on a wooden frame provided with lifting chains and rings. The engine is bolted to a strong gun-metal bracket, which in turn is connected to the pump by means of three strong steel distance bars. The pump casing and impeller are of gun-metal and the shaft of phosphor bronze. The engine is capable of developing up to 8 brake horse-power, at a maximum speed of 1,800 r.p.m. to 1,900 r.p.m., but normally works at from 1,200 r.p.m. to 1,500 r.p.m. The maximum delivery is from 80 tons to 90 tons per hour. The engine is fitted with magneto ignition. It is arranged for hopper cooling. The tank for holding the water supply has connections carried to an annular space in the pump suction cover for cooling purposes. The set can easily be carried by two men, its weight being about 2 cwt.

In our issue of July 4, p. 2 *ante*, we dealt with some of the pumps exhibited at the stand of Messrs. Gwynnes Engineering Company, Limited; in Figs. 42 and 43, above, we illustrate a further exhibit by this firm, in the form of a steam turbine boiler feed pump. The combination is mounted on one bed plate. The pump casing, of cast steel, is split horizontally and vertically, the former allowing the impeller and rotor to be lifted out on the shaft, while the latter enables a better finish to be given to the volute and also allows the impeller to be drawn off independently of the rotor. The impeller is of bronze and of the double-entry type, end thrust being thus eliminated. The shaft is supported in ring-oiled bearings on both sides. The casing eye is fitted with gun-metal rubbing rings giving sufficient clearance for handling hot-well water up to 200 deg. F. The steam turbine is of the two-stage impulse type with ring-oiled bearings, casing and bearings, being split horizontally. The unit is non-condensing. The main stop valve has a safety trip which operates if the load is suddenly released. An automatic regulator is also fitted to control the speed according to variation of boiler pressure, being operated by the steam pressure acting on a diaphragm. Primary and secondary nozzles are utilised. The set runs at from 4,000 r.p.m. to 6,000 r.p.m., with a boiler pressure of 250 lb. The 2½ in. size shown delivers 60,000 lb. of water per hour against 250 lb. boiler pressure; other sizes capable of delivering 150,000 lb. and 250,000 lb. per hour are also made.

In connection with the pumping of sewage and other liquids containing solids, Messrs. Gwynnes have introduced the Gwynne-Pennell rotary trap, which may be used with centrifugal pumps of high efficiency. The low efficiencies of pumps with impellers with large passages are thus avoided, while for sewage the apparatus can replace the ejector system. The latest arrangement of the Gwynne-Pennell trap as exhibited at the firm's stand at Wembley, is illustrated in Figs. 44 to 49, above, and on page 219. Of these, Figs. 45 and 46 show the complete installation with vertical spindle centrifugal, trap and motor. Fig. 44 is a view of the set without, however, the motor, which is mounted on the circular column base to the right. Fig. 47 shows a section of the trap, while Fig. 48 is a diagram set out so that the operation may be readily followed. Fig. 49 is a trip gear to prevent the trap being jammed by large solids, as will be explained later. Both trap and pump are driven by the motor, the former having a speed of about 5 r.p.m. to 10 r.p.m. The pump draws through the trap and delivers back into the trap. Any solids are caught in the trap and prevented from entering the pump, but are delivered again to the discharge stream and carried away.

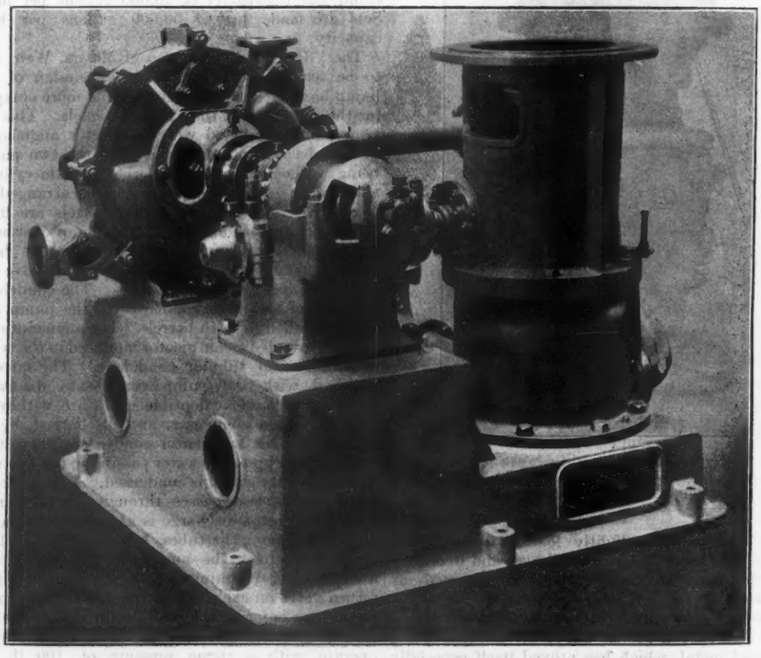


Fig. 44. The Gwynne-Pennell Rotary Trap; Messrs. Gwynnes Engineering Company, Limited.

The trap consists of a spider mounted on a shaft and enclosed on each side by circular screens. This revolves inside a casing fitted with two side covers. The latter contain ports and passages, in conjunction with connections to and from the pump. The liquid drawn in through the suction enters the body of the trap. Everything able to do so is passed through the rotating side screens to the passages in the covers connected with the pump suction. Solids are held in the pockets inside the revolving trap between the spider arms. The liquid, after passing through the pump, is returned through the second set of passages in the covers, and the revolving screens, to the interior of the trap, through which they pass to the discharge. In the meanwhile the revolving spider has brought trapped solids opposite the discharge also, and these are swept away by the stream delivered. The screen, in revolving, is thus constantly cleared of fibrous and stringy material which may be clinging to the bars from the first straining. The arms prevent direct communication between the suction and delivery ports, the clearance allowed only permitting a negligible amount of leakage. The screens consist of a number of concentric rings of approximately

PUMPING MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. GWYNNES ENGINEERING COMPANY, LIMITED, ENGINEERS, HAMMERSMITH.

Fig. 45.

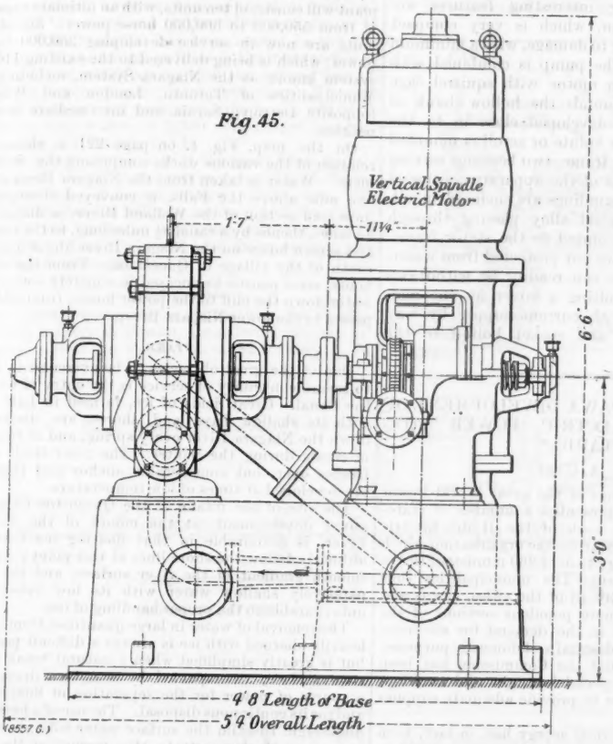


Fig. 46.

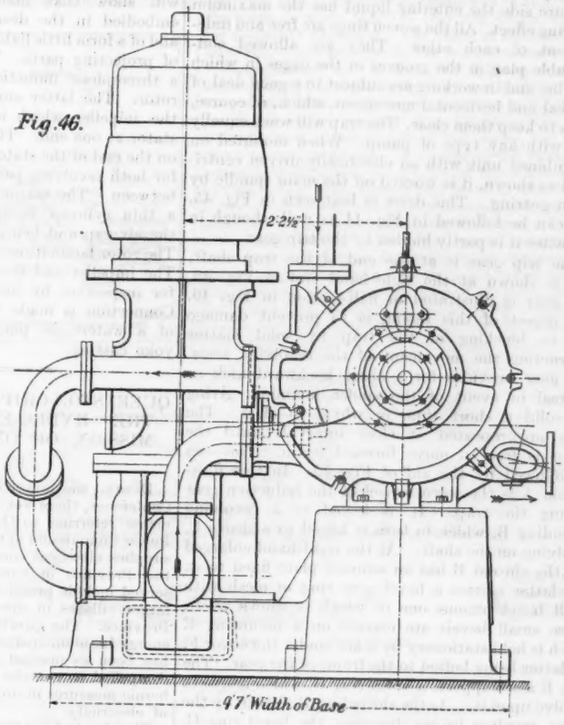


Fig. 47.

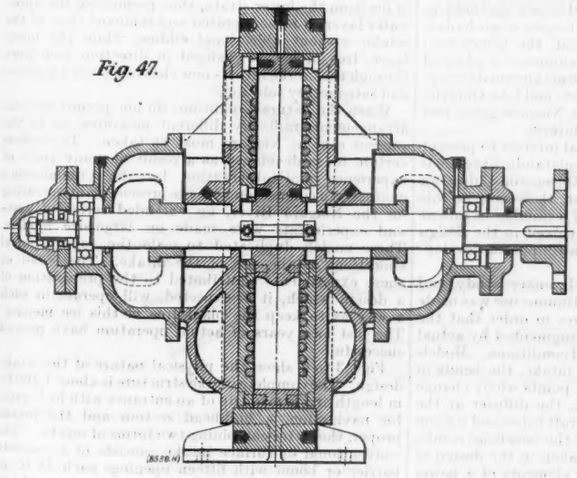


Fig. 48.

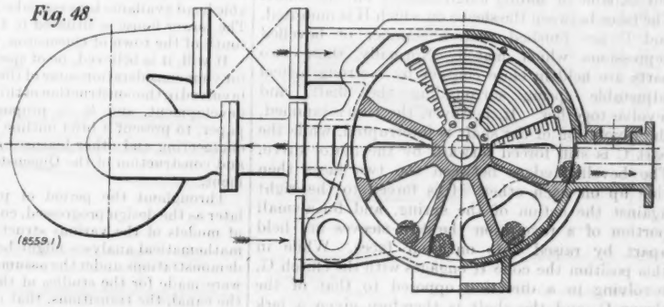
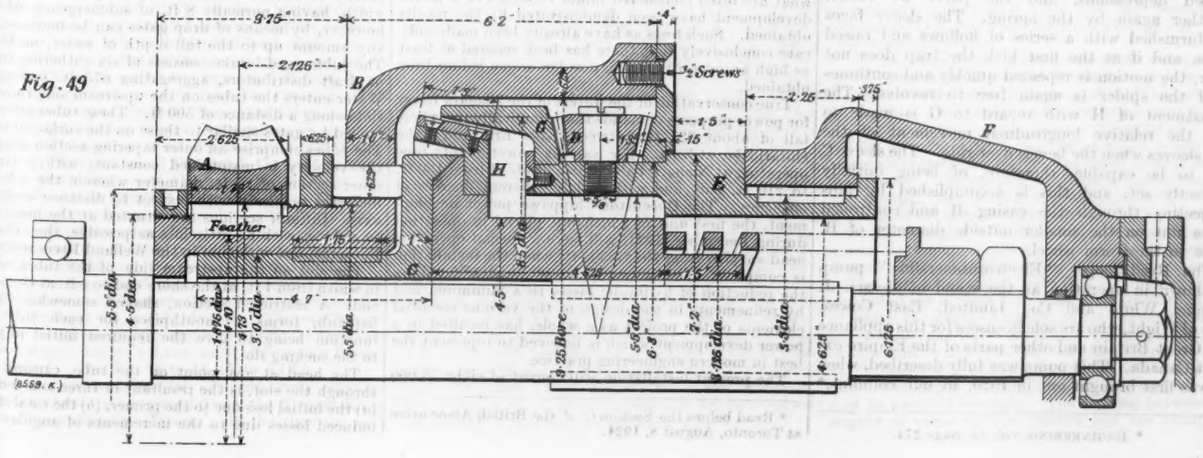


Fig. 49



triangular cross-section with the apices of the triangles outwards, so that it is difficult for solid matter to pass between the rings, but any which actually do so is immediately cleared, while on the pressure side the entering liquid has the maximum scouring effect. All the screen rings are free and independent of each other. They are allowed considerable play in the grooves in the cages in which they lie, and in working are subject to a good deal of vertical and horizontal movement, which, of course, tends to keep them clear. The trap will work equally well with any type of pump. When mounted on a combined unit with an electrically driven centrifugal as shown, it is worked off the main spindle by worm gearing. This drive is best seen in Fig. 45, and can be followed in Fig. 44 as well, though in the latter it is partly hidden by the trip gear.

The trip gear is at the end of the trap shaft, and is shown at the right-hand end in Fig. 45. The gear is illustrated in half-section in Fig. 49. The object of this fitting is to prevent damage due to blocking of the trap by solid matter obstructing the movement of the revolving arms. The gear provides for a short backward kick or reversal in event of the spider jamming, giving the solid a short time in which to clear. The kicks are repeated at close intervals until the spider is free to move forward again. This can be followed by the aid of Fig. 49. In this illustration A is the worm wheel of the reduction gear driving the trap. It is keyed to a revolving shrouding B, which in turn is keyed to a sleeve C, revolving on the shaft. At the right-hand enlarged end the shroud B has an annular plate fixed to it. The latter carries a bevel gear ring in mesh with small bevel pinions one of which is shown at D. These small bevels are carried on a mounting E which is held stationary by a key under the cover F, the latter being bolted to the frame of the gear. The part E also supports a bevel ring G, which is free to revolve upon it. As the shrouding B, driven by the worm, revolves in one direction, the bevel ring G, driven by the bevel D, revolves in the opposite sense. It will be noticed that G has a projecting cone rim. This forms one part of a clutch, the mating part of which H is carried by a sleeve revolving with, but capable of sliding longitudinally on, the shaft. The faces between the sleeve on which H is mounted, and C are finished with a number of bevelled depressions which match. Normally, these two parts are held in close contact by a strong helical adjustable spring surrounding the shaft, and revolve together. If, however, the trap is jammed, the revolution of the shaft is interrupted, while the part C is still forced forward by the motor drive. The bevelled edges between the two faces then ride up on each other, H is forced to the right against the action of the spring, and for a small portion of a revolution the two sleeves are held apart by raised flats on their faces. While in this position the cone H engages with the clutch G, revolving in a direction opposed to that of the sleeve C, and the shaft is therefore given a jerk in this new direction, the movement terminating when the raised flats on the sleeve faces, instead of being in contact, mate again with correspondingly shaped depressions, and the parts are closed together again by the spring. The sleeve faces are furnished with a series of hollows and raised parts, and if at the first kick the trap does not clear, the motion is repeated quickly and continues until the spider is again free to revolve. The adjustment of H with regard to G is made to suit the relative longitudinal movement of the two sleeves when the bevels over-ride. The sleeve C has to be capable, therefore, of being initially correctly set, and this is accomplished by pins projecting through the casing B and controlled by a nut on the smaller outside diameter of B, close to the worm wheel.

The Reed-Cooper "Electrosubmersible" pump is shown in operation at the stand of Messrs. J. Samuel White and Co., Limited, East Cowes, Isle of Wight, who are sole licensees for this appliance for Great Britain and other parts of the Empire except Canada. This pump was fully described, when it was first brought out in 1920, in our columns,* and in principle has remained unchanged in the interval. It has met with good success, having been adopted by the British Admiralty and the Japanese Navy. A reference to our former article will show that many interesting features are embodied in the design, which is very compact and of a form little liable to damage, with a minimum of projecting parts. The pump is combined with a three-phase induction motor with squirrel cage rotor. The latter surrounds the hollow shank of the impeller which is developed close in to the stator at one end. The volute or scroll is mounted on the end of the stator frame, two bearings serving for both revolving parts of the apparatus, situated between. The stator windings are enclosed in oil, a thin cylinder of special alloy passing through the air gap and being jointed to the stator frame. The rotor laminations are not protected from water. The impeller and rotor can readily be withdrawn for inspection by unbolting a cover at one end. Connection is made with current supply by way of a watertight plug and socket bolted to the yoke casting.

* Engineering, vol. cx, page 274.

QUEENSTON-CHIPPAWA DEVELOPMENT OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.*

By F. A. Gaby.

During the proceedings of the great World Power Conference, there were presented a number of statements referring to the work of the Hydro-Electric Power Commission of Ontario—the organisation which supplies electrical energy to over 360 municipalities in the Province of Ontario. The municipalities thus served include practically all of the cities, towns and larger villages in the more populous sections of the Province. The growth in the demand for electrical energy for municipal, industrial and domestic purposes, has been so marked that the Commission has been compelled to exercise special foresight and to adopt heroic measures in order to provide adequate supplies of electricity.

The demand for electrical energy has, in fact, been such that the Commission, in 1917, felt justified in commencing construction upon the largest single hydro-electrical power plant in the world, the Queenston-Chippawa development. This development is situated on the Niagara river and utilizes the maximum developable head available between lake Erie and lake Ontario. The power house is situated in the Niagara gorge just south of the town of Queenston, Ontario.

It will, it is believed, be of special interest to present for your consideration some of the outstanding problems involved in the construction of this Queenston-Chippawa development, and it is proposed, therefore, in this paper, to present a brief outline of a number of salient engineering and other features involved in the design and construction of the Queenston-Chippawa development.

Throughout the period of preliminary study and later as the design progressed, continuous use was made of models of the various structures in order that the mathematical analyses might be augmented by actual demonstrations under the assumed conditions. Models were made for the studies of the intake, the bends in the canal, the transitions, that is, points where change of section occurred in the Canal, the diffuser at the mouth of the forebay, and of the draft tubes and station substructure. It is believed that the beneficial results of such studies and of the care taken in the design of what are often considered minor elements of a power development have been demonstrated by the results obtained. Such tests as have already been made indicate conclusively that there has been secured at least as high an over-all efficiency as has every before been obtained.

True conservation of the waters of the Niagara River for power purposes demands that practically the whole fall of about 327 ft. between Lake Erie and Lake Ontario be utilised. The various power plants now operating at Niagara Falls utilize heads of from 130 ft. to 210 ft. only and with widely different degrees of efficiency. The Queenston-Chippawa power development, the first unit of which was placed in operation during December, 1921, will have a normal operating head varying from 294 to 305 ft. when the installation is complete. The conservation of head effected by the reduction of hydraulic losses to a minimum, and by refinements in the design of the various essential elements of the project as a whole, has resulted in a power development which is believed to represent the best in modern engineering practice.

The present installation will consist of eight 55,000 to 60,000 horse-power turbine units operating at 187·5 revolutions per minute. The generators are of 45,000 to 55,000 kv.-a., capacity at 12 kv., 3-phase, 25 cycles. The electrical energy is transformed from 12 kv. to 110 kv. for transmission. Eventually, the plant will consist of ten units, with an ultimate capacity of from 550,000 to 600,000 horse-power. Six of the units are now in service developing 350,000 horse-power, which is being delivered to the existing 110 kv. system known as the Niagara System, including the Municipalities of Toronto, London and Windsor (opposite Detroit), Sarnia and intermediate municipalities.

On the map, Fig. 1, on page 221, is shown the relation of the various works comprising the development. Water is taken from the Niagara River about one mile above the Falls, is conveyed through the improved section of the Welland River, a distance of 4½ miles, thence by a canal 8½ miles long, to the forebay and screen house on the Niagara River about one mile south of the village of Queenston. From the screen house, steel penstocks encased in concrete convey the water down the cliff to the power house, from which it passes to the lower Niagara River.

Intake.

One of the great obstacles to be overcome in order to secure continuity of service is the entry of ice into the Canal. Great fields of ice, formed in Lake Erie with its shallow bays and shores, are discharged down the Niagara River every spring, and at frequent intervals during the winter. The river itself never freezes over, but considerable anchor and frazil ice are developed at times of low temperature.

The site of the intake of the Queenston-Chippawa power development, at the mouth of the Welland River, is favourable in that floating ice does not ordinarily follow the shore lines at this point; but the smooth gradient of the river surface, and the comparatively shallow water with its low velocity, is unfavourable to the proper handling of ice.

The removal of water in large quantities from a river heavily charged with ice is always a difficult problem, but is greatly simplified when a natural break in the river surface, accompanied by a sudden drop, gives a source of power for the separation of floating ice, and for its continuous disposal. The use of a horizontal diaphragm to skim the surface water with its burden of ice from the lower strata, thus permitting the upper water layer to be accelerated and removed clear of the intake without objectional eddies, while the lower layer, free of ice, is changed in direction and flows through the intake into its new channel, gives a positive and satisfactory solution.

When the natural conditions do not permit such an arrangement, radically different measures, as in the present case at Niagara must be taken. To confirm certain ideas developed as a result of many years of experience and observation by the Commission's engineers in connection with the present plant operating on the Niagara River, an extended series of tests and experiments were made on large-size models. These models duplicated to scale the topographical conditions at the site of the intake. The result of these experiments contributed to the preparation of a design which, it is expected, will operate in such a way as to keep the plant free of this ice menace. The last two years of actual operation have proved successful.

Figs. 3 to 6 show the physical nature of the intake design. The complete intake structure is about 1,100 ft. in length and is made up of an entrance with lock gates for navigation, a bulkhead section and the intake proper, the latter combining two forms of intake. The conventional or surface intake consists of a concrete barrier or boom with fifteen openings each 18 ft. in width, having normally 8 ft. of submergence, which, however, by means of drop gates can be increased to any amount up to the full depth of water, or 35 ft. The submerged intake consists of six gathering tubes or draft distributors, aggregating 675 ft. in length. Water enters the tubes on the upstream side through slots along a distance of 500 ft. These tubes are controlled by gates similar to those on the surface intake. The tubes comprise an outer tapering section wherein the velocity is maintained constant, with a longer inner section of 20 ft. diameter wherein the velocity increases regularly with respect to distance along its axis. Diffuser sections are situated at the inner end to reduce, with as little loss as possible, the velocity to correspond with that in the Welland River section.

The slot on the upstream side of the tubes varies in width from 1 ft. at the shore end to 4 ft. at the outer end. A restricted section, shaped somewhat like a bathtub, forms a mouthpiece for each tube, its function being to give the required initial impulse to the sucking slot.

The head at any point on the tube, causing flow through the slot, is the resultant of three components (*a*) the initial loss due to the primer, (*b*) the total of the induced losses due to the increments of angular flow

* Read before the Section G of the British Association at Toronto, August 8, 1924.

through the slot, and (c) the total cumulative friction head in the tube, including velocity head.

The designed rate of total inflow through each slot is 2,500 cub. ft. per second along the axis of the tube. The rate of inflow per lineal foot of slot has not been chosen uniform, however, because the river feeds more water at the outer end of the tubes than nearer the shore. This variation has been chosen in the ratio of four at the outer end to three at the inner end of the slot, a factor which agrees with the natural flow distribution under present river conditions. The total loss of head in each gathering tube to the end of the diffuser, with a flow of 2,500 cub. ft. per second in each tube, will be only 0·3 ft.

During the greater part of the year, when no ice is running in the river, the intake gates of both the surface and the submerged intakes will be open. The navigation channel will also be open and the velocity through the intake at any point will, therefore, be very low, so that the loss of head under ordinary conditions will be negligible.

THE CANAL.

For many miles above its mouth the Welland River is a sluggish stream, meandering slightly in a depression that can hardly be called a valley. This stream for 4½ miles forms the first reach of the canal, and its low banks provided a suitable disposal area for much of the material excavated in the process of straightening and deepening the channel. The radius of curvature of some of the bends is increased in the new alignment, but the old channel location is largely followed. The velocity under full-load conditions will be low, being limited by the scouring velocity for the clay soil through which the improved channel is cut. Leaving the river channel near the crossing of the Michigan Central Railway the canal takes a course almost due north for over three miles, as shown in Fig. 1. The earth over-burden is quite heavy for the whole of this portion of the canal, the bottom grade of the earth section of the canal meeting the rock surface one mile from the Welland River. The maximum rock elevation is not coincident with the maximum earth surface elevation, but the profiles of rock and earth surface are roughly parallel to each other. Just beyond Lundy's Lane the maximum bend in the canal occurs, having a deflection of 51 degrees, and, at intervals, of a little over a mile each there are two other bends of 27 and 31 degrees. The earth over-burden continues fairly uniformly (Fig. 2) for three miles beyond Lundy's Lane until Bowman's Ravine is reached. (See Fig. 12 to 14, Plate XIX).

The ravine is apparently an old river channel through which, in pre-glacial times, the Niagara River flowed towards Lake Ontario. At the time the construction started, this old channel was the course of a small stream having its outlet at the Whirlpool. The ravine crossing is made on a fill and the ravine itself proved a convenient disposal area for about 1,500,000 cub. yards of excavated material. Where the canal section again enters the rock cutting beyond the ravine, the earth over-burden becomes very light, in some places amounting to only a foot or so. Two deflections are made in the remaining two miles of the canal, one of 33 and the other of 47 degrees. A quarter mile beyond the second of these curves the forebay (Fig. 7 above and Fig. 16, Plate XX) is reached.

Fig. 1.

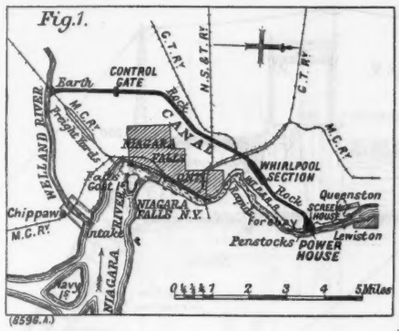


Fig. 2.

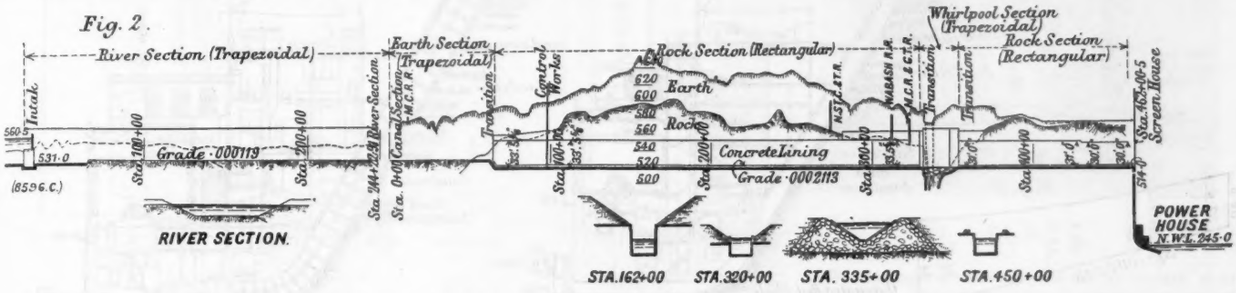


Fig. 3. PLAN.

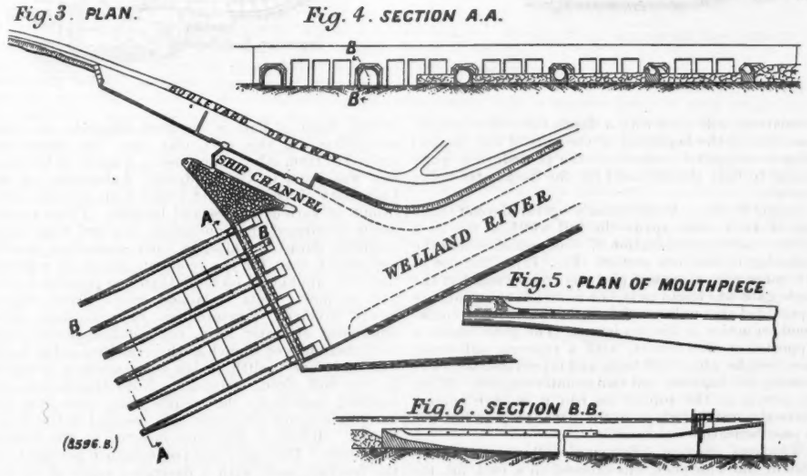
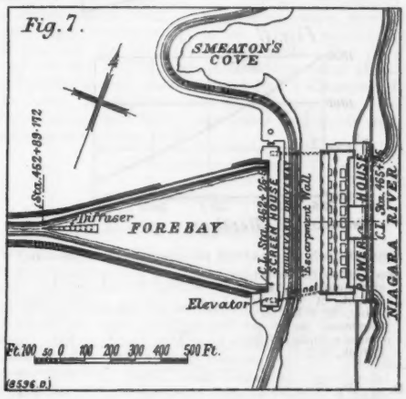


Fig. 4. SECTION A.A.

Fig. 5. PLAN OF MOUTHPIECE

Fig. 6. SECTION B.B.

Fig. 7.



Economy Studies.—The procedure in determining the economic proportions of the canal will briefly be outlined. It is essential that the canal carry the full quantity of water required under the lowest conditions of water level in the Niagara River. A series of tentative canals were designed, each of 48 ft. width and capable of carrying the required supply of water with uniform flow and on the assumption of low water in the Niagara River at Chippawa. The first of the series was of such a depth that the velocity would be 4 ft. per second, and the designed slope of the bottom and water surface was the requisite slope for uniform flow, the others being designed for higher velocities. The width of 48 ft. above mentioned was determined after study of the excavating plant available.

The cost of each of these canals was calculated, and a curve was plotted showing the relation between low-water velocity and cost. From this curve the tangents were scaled for various low-water velocities. For low velocity the canals will be deep and therefore costly. For very high velocities the canals will be shallow, but the slope so steep that the cost will be greater than for moderate velocities. The canal of minimum cost, however, is not necessarily the most economical.

Enlargement will reduce the friction loss and, consequently, increase both the head and the power output at a cost which, up to a certain point, is both justifiable and economic. The determination of the economic size is based, not on low water, but on the mean water conditions. For each of the canals thus tentatively designed, the profile of the water surface corresponding with mean water level in the Niagara River is computed, thus determining the friction loss and the lost power at mean water stages. Tangents were scaled from a "lost power curve" plotted from these results and were divided into the tangents from the "lost power curves" for each low water velocity. The dividend in each case is the cost per horse-power of the power gain at the particular velocity to which the results respectively apply. These dividends are next plotted against low-water velocity, thereby developing an "economy curve" from which the economic velocity may be selected.

Slight changes in the head give increases in power without appreciable change in operating or maintenance costs, and the only essential charge against power gained by slight enlargements of the canal is the interest charge on the cost of enlargement. The economic velocity, therefore, is one corresponding on the "economy curve" to a total cost per horse-power, considerably higher than the total average cost of the whole development.

In the computation of the profile of the water surface of the various canals studied, the surface slope in nearly all cases was different from the profile of the bottom of the canal. The conditions thus existing were those of non-uniform flow. As numerous computations of the profile of water surface were to be made, a rapid and convenient method of computing these profiles became a necessity. The method, while involving nothing new in principle, may perhaps be of interest and value on account of the details of procedure. In the cases considered, examples of both backwater and dropdown curves were met. Only a minor change in procedure is necessary to change from one to the other.

The various channels for which a surface curve is computed are divided into a series of reaches, in each of which the depth-change is equal although small—for example, one-tenth of a foot. The lengths of these reaches will be different, but the change in length will vary consistently from reach to reach, and within each reach, the depth change being slight, uniform flow may be assumed to apply. The relation between the lengths of these various reaches and the change in

depth determines the surface curves. As the changes in lengths vary consistently from reach to reach, it is necessary to compute only four or five values of the lengths for different depths and plot the lengths against the corresponding depths.

Fig. 8.

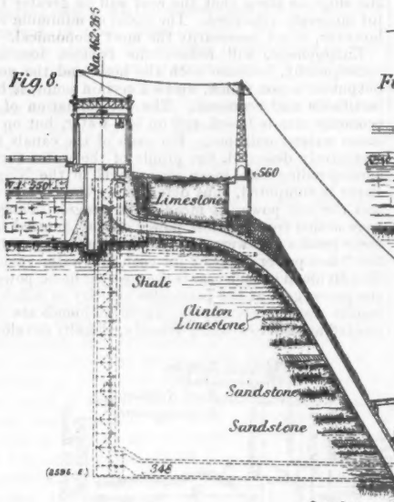


Fig. 9.

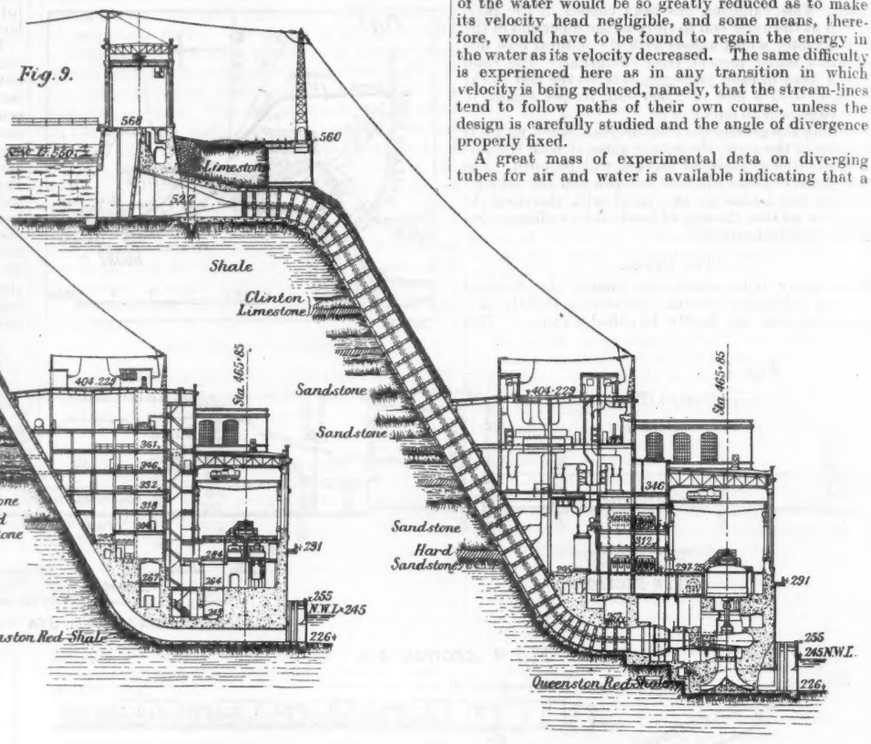


Fig. 10.

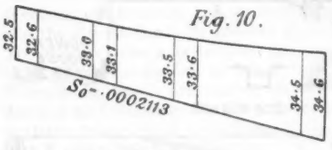
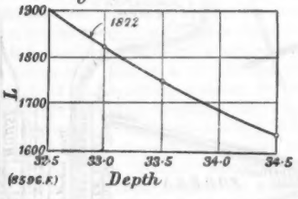


Fig. 11.



PROFILE OF CANAL—STATION 65 + 00 TO STATION 200 + 00.

Q = 13,000 c.f.s. Depth at beginning, 32·711′; Height of concrete lining, 32′; Kutter's roughness factor in concrete lining, ·012; in rock, ·033.

$$\Delta D = D_2 - D_1 = \cdot 1$$

$$\Delta h_v = h_{v1} - h_{v2} = \frac{V_1^2 - V_2^2}{2g}$$

$$\frac{(V_1 - V_2)(V_1 + V_2)}{2g}$$

D.	V.	Δh_v	r.	n.	c.	s.	L.
32·5	8·353	·0068	13·986	·01209	175·3	·0001623	1902
32·6	8·327						
33·0	8·223	·0065	14·081	·01228	173·1	·0001602	1830
33·1	8·198						
33·5	8·098	·0062	14·172	·01246	171·1	·0001580	1760
33·6	8·073						
34·5	7·858	·0057	14·352	·01282	167·3	·0001538	1641
34·6	7·835						

$$L = \frac{\Delta D - \frac{(V_1 - V_2)(V_1 + V_2)}{2g}}{S_o - \frac{V^2}{C^2 r}}$$

L = Length of section for increase in depth of 0·1′ at various depths; Q = 13,000; n = ·012 in concrete; ·033 in rock; depth at beginning, 32·711; distance to reach $32·8 = \frac{·089}{·100} \times 1872 = 1666$.

These distances scaled from curve on left for depths increasing by 0·1′ ..

1,859	
1,841	
1,830	
1,815	
1,800	
1,790	12,601
1,775	
1,760	

Distance from station 65 + 00 to station 200 + 00 = 13,500′; in 12,601′ depth has increased to 33·4; remaining distance to station, 200 = 899′; increase in depth = $\frac{899}{1775} \times ·1 = ·051$; depth at station, 200 = 33·451.

An example of the computation of a surface curve is shown in Figs. 10 and 11. In connection with this it should be explained that Kutter's formula has been used and the roughness factor n has been varied to make allowance for increasing roughness as the depth increases because the height of the concrete lining is less than the depth of water in the canal.

If the discharge and depth are such as to demand a slope of water surface greater than the slope of the bottom, the case is that of the drop-down curve. The calculations will start with a depth somewhat greater than that at the beginning of the part of the channel being investigated; otherwise the procedure is quite similar to that already used for the backwater curve example.

Control Works.—An electrically-operated roller sluice gate of 48 ft. clear span—the full width of the rock section—is located at station 97 + 00, which is near the beginning of the rock section (Fig. 17). The use of two gates with a central pier was considered, but the single gate was found to be the more advantageous, as it provided an unobstructed waterway, with a consequent reduction in friction losses. The gate, which is supported on steel towers, with a concrete sub-structure, weighs about 100 tons, and is provided with two hoisting mechanisms and two counterweights. When the gate is at the top of its run it is high enough above the water surface in the canal to permit a tug to pass beneath.

Whirlpool Section.—Bowman's Ravine, situated west of the whirlpool, was crossed on a rock fill, the cross-section of the canal being changed from a rectangular section 48 ft. in width, to a trapezoidal section with 10 ft. bottom width and side slopes of 1 in 1½. This cross-section was designed to give as great a cross-sectional area as the rock section has at the extreme minimum water level. The whirlpool section is lined with reinforced concrete. In order to withstand the pressure of the back water when the canal is emptied, the lining is provided with vents of sufficient size to drain the fill as quickly as the water can be drawn down in the canal.

Concrete Lining—Economic considerations prompted the lining of the canal with concrete. The height of the lining was fixed slightly lower than the profile of the water surface existing when the load conditions on the plant are at a maximum and the flow in the Niagara River is at a minimum. Thus, at all times, the lining will be protected by submergence against the action of frost. The thickness of the lining varies according to the rock over-break but averages about 20 in., and where necessary, steel dowels are used to anchor the concrete lining to the rock.

Extreme smoothness of surface is not the only determining factor but precise alignment is also a most important element in the reduction of hydraulic losses. Great care was taken to obtain a smooth surface by the use of steel forms, and for this purpose a positive and rigid method of form setting was devised. This insured almost perfect alignment. The results obtained were excellent, and it is expected that when opportunity offers to test the efficiency of the lined section of the waterway an extremely low factor of roughness will be realised.

The Forebay.—The kinetic energy of the water at the end of the canal and at the entrance to the forebay had to be considered. In the forebay the velocity of the water would be so greatly reduced as to make its velocity head negligible, and some means, therefore, would have to be found to regain the energy in the water as its velocity decreased. The same difficulty is experienced here as in any transition in which velocity is being reduced, namely, that the stream-lines tend to follow paths of their own course, unless the design is carefully studied and the angle of divergence properly fixed.

A great mass of experimental data on diverging tubes for air and water is available indicating that a 10 deg. angle of flare is the most efficient. In order to confirm, for this particular case, the conclusions arrived at from other experiments, a model of the forebay was built in the Hydraulic Laboratory of the University of Toronto, and tested with nineteen transitions of various angles and lengths. These experiments confirmed the conclusions reached from other available data, and also, in their quantitive results, provided a basis for the economic design of a transition that would cost no more than was justified by the gain in power from reclaimed head. These experiments involved measurement of extremely small differences of water level, necessitating observations to thousandths of an inch as the velocities in the model were only one-twelfth of the corresponding velocities in the full sized structure. Notwithstanding this exacting condition, the results were, with very few exceptions quite consistent and resulted in the design of the "diffuser" structure inserted in the forebay transition. This provided two entrance passages into the forebay, each with a diverging angle of 10 deg. (Fig. 7). The diffuser is a wedge-shaped structure 221 ft. long and 37 ft. wide at the downstream end. The sides are vertical, straight and smooth and extend 28 ft. above the bottom of the forebay. An opening 16 ft. by 20 ft. in the end wall assures about equal pressures on both sides of the walls.

Through this diffuser expedient, the high velocity at the end of the canal is gradually reduced and its kinetic energy recovered, with the result that the elevation of the water in the forebay will be higher than at the mouth of the canal. For a flow of 15,000 cub. ft. per second, and mean water level at Chippawa, it is estimated that the reclaimed head will amount to approximately 1 foot. Observations made some months ago with a flow of 6,818 c.f.s. showed a water surface elevation at the screenhouse 0·21 of a foot higher than at the end of the canal.

Screen House.

At the lower end of the forebay, and serving as a dam for the same, is located the screen house. This structure forms the entrance, and the control, for the penstocks. The entrance to each of the main penstocks is a modified bell-mouth consisting of three openings 12 ft. 8 in. wide and 29 ft. high at the rack supports. These three openings gradually converge into one opening 16 ft. in diameter at the point of connection to the penstocks. In designing these water passages, particular care was given to the securing of smooth stream lines and consistent changes in velocity.

BALANCED MANOMETER AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. GEORGE KENT, LIMITED, ENGINEERS, LUTON.

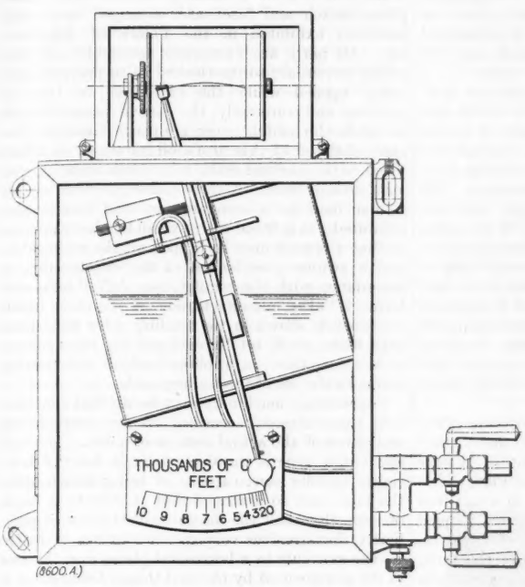


FIG. 1.

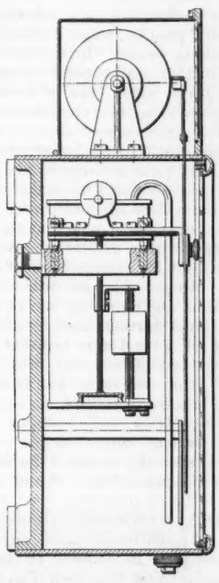


FIG. 2.

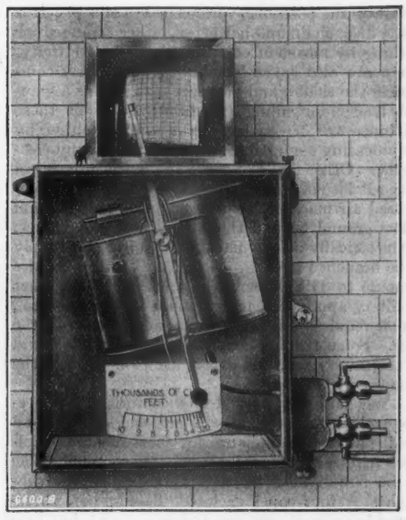


FIG. 3.

The bell-mouth entrances are sealed by a concrete curtain wall extending down to elevation 542·0 which gives a depth of 28 ft. above the floor of the forebay. Immediately behind the curtain wall steel-lined gate checks are provided to support structural steel gates. These provide a means of unwatering in case it is necessary to inspect the lower sections of the racks, or the penstocks. The intake is divided into three waterways in order that the spans for the gates may be of convenient size and also to permit the use of racks of a somewhat new design. The racks, which consist of 3 in. by $\frac{3}{8}$ in. bars on edge, 5 in. centres, are fastened rigidly to a structural steel supporting frame held in checks in the concrete walls. The whole of the rack structure is removable and is split horizontally into two sections for convenience in handling. A specially designed rack follower with an automatic latch arrangement is provided to facilitate the removal of the racks, the bottom section being a considerable distance below the floor of the screen house. The bars and the supporting structure of the racks are designed to withstand a head of 10 ft. with a stress of 20,000 lbs. per square inch on the steel. This type of construction removes the danger of serious shut-down due to the collapse of rack structures, as in the event of blocking by ice or other foreign matter, the failure of one section would immediately relieve the others. The broken section can then readily be replaced with a spare one without serious interruption to operation.

A trash trench of liberal dimensions extends across the bottom of the forebay immediately in front of the screen-house piers to collect any debris or foreign material which may travel along the bottom of the forebay. The piers dividing the main unit entrances are 6 ft. in thickness, while the two intermediate piers in each unit are 3 ft. thick. The main dividing piers are designed for full water pressure on each side in order that any unit of the intake may be unwatered while the adjacent units are in operation. An opening in the main floor immediately behind the racks provides a means of disposal of trash into a trough, which empties into the ice chute. The screen house, as constructed, provides for nine main units, a service unit and an ice chute, and is arranged so that a further unit entrance may be added at the north end.

The entrance to the service unit is similar to the main unit, except that it consists of one bay only, and the entrance to the penstock itself is a true bell-mouth instead of the sectionalised transitions in the main unit entrances. The ice chute bay has a clear width of 25 ft., and is provided with a roller-type sluice gate, which is lowered to pass surface water carrying ice. After passing the gate the water and ice enter a concrete pipe 10 ft. in diameter and pass down the cliff, out beneath the power house, into the Niagara River. Stop log checks are provided ahead of the gate for use in an emergency, or for inspection purposes.

The screen house is located near the edge of the escarpment, only a narrow ledge of rock being left between it and the gorge. Owing to the disastrous results which would follow a failure, the screen house substructure was designed to resist the full head exerted by the water in the forebay. The superstructure is built with reinforced concrete walls and a roof with a structural steel framework, and is equipped with a 25-ton capacity electrically-operated travelling crane for handling the racks and gates. At the south end of the screen house proper, an enlargement of the building provides for administration offices, and an entrance to the elevator and the tunnel, which give access to the generating station.

PENSTOCKS.

From the screen house the water is carried to the turbines in steel penstocks (Figs. 8, 9 and 15). The first five unit penstocks are 16 ft. in diameter for approximately two-thirds of their length, and are then reduced by a taper section to a diameter of 14 ft. The remaining penstocks are 16 ft. in diameter for their complete length. In the penstocks there are two bends, one located at the top and one at the bottom. These elbows are held in massive concrete anchor blocks, the one at the upper bend forming a foundation for the piers supporting the sidewalk and roadway extending along the edge of the escarpment.

Each penstock ring is made up of two plates with longitudinal joints on the horizontal centre line. The joints are all double butt, varying from double riveted at the top to quadruple riveted at the lower end. The circumferential joints are also single butt, double riveted with the butt strap on the outside. The longitudinal joints are calked on the inside, but the circumferential joints are made watertight by electric welding. This type of circumferential joint gives a much better alignment to the inside of the pipe than can be obtained with the usual outside and inside course with lap joints. The penstocks were designed for a stress of 12,000 lb. per square inch. The internal pressure, used for the design, was taken to be the static head, plus the pressure rise due to a complete closing of the turbine gates in 1½ seconds. This increase in pressure was taken as a maximum at the turbine gates and varying uniformly to zero at the racks.

The plates vary in thickness from $\frac{1}{2}$ in. at the top section to 1$\frac{1}{4}$ in. at the lower section. The longitudinal butt straps are $\frac{1}{2}$ in. thick with two rows of $\frac{7}{8}$ in. rivets for the lightest joint and $\frac{11}{16}$ in. thick with four rows of 1$\frac{1}{8}$ in. rivets for the heaviest. The efficiency of the longitudinal joints at the heavy section is about 85 per cent. In the erection of the penstocks, a new departure was made by the use of electric rivet heaters. The penstocks are covered throughout the entire length with a concrete envelope, having a minimum thickness of 24 in. which protection will increase the life of the steel pipes. The per-stock for the service units follows the same alignment as the main penstocks, and has a diameter of 5 ft. 6 in. As friction loss in this pipe was not such an important factor, lap joints and inside and outside courses were used.

(To be continued.)

BALANCED MANOMETER.

WE illustrate in Figs. 1 to 3 above, a manometer which is being shown at the stand of Messrs. George Kent, Limited, at the British Empire Exhibition. The appliance is intended for measuring and recording the flow of air and gases through orifices, or by the use of a Pitot tube or other means of obtaining differential pressures. The manometer consists of two closed vessels containing liquid, and connected together at the bottom. The vessels are balanced about a knife edge, a screwed counterweight being provided for adjustment purposes. Each vessel is coupled by flexible tube to a cock, which in turn is connected with one side of the orifice or one orifice of the pitot tube. The difference of pressure which results in the two vessels when any flow takes place, causes the liquid to be transferred from one vessel to the other in an amount corresponding to the difference produced. The centre of gravity of the balanced part is thus altered, and the indicator pointer moves across the scale until conditions of equilibrium are brought about. The balance gear is provided with an arm projecting upwards into a case in which is a clockwork-recording drum, and its upper end is furnished with a pen, which accordingly traces on the chart a curve indicating the flow of gas. The instrument is designed to work at a head of 2-in. water gauge. The counterpoise is used to set the indicator to zero.

GEAR MEASUREMENT.—A pamphlet giving full particulars of the measurements they are prepared to make on gear wheels of all descriptions has been prepared by the Metrology Department of the National Physical Laboratory and is obtainable from the Director of the Laboratory, Teddington, Middlesex. For some time past, the subject of gear measurement has been receiving attention at the Laboratory and a special machine has been designed and constructed for this work. The machine, we may mention, was illustrated and fully described in our issue of July 27, 1923, on page 104. The methods employed are such that the errors in all the various elements of the gear dimensions are determined separately, so that the cause of any unsatisfactory working can be traced to its source in the cutting process. The measurements made are explained in detail in the pamphlet, and particulars of the fees charged are given.

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 193.)

In the mine at Wembley there are exhibited in their working positions, various makes of coal cutter of the disc, chain and bar types, either arranged for working by means of compressed air or electricity. There are also several makes of conveyor, comprising the shaker and belt types, as well as a gate-end loader for filling the tubs; some of these machines are driven by compressed air either by reciprocating engine or turbine, and others by electricity. Other types of these appliances are shown in the Palace of Engineering, and whereas the compressed air machines require no special installation below ground beyond the supply pipe and valves, the electrically-driven machines require their supply to be branched to each. As the coal cutters require some 25 to 35 h.p. each, the total, including other auxiliary appliances, may amount to some 60 h.p., which requires its own switchgear adjacent to the face. Some examples of switchgear are to be found in the mine itself, and others are to be seen in the Palace of Engineering.

A mechanically worked face comprising an electric coal cutter, a conveyor, a gate-end loader, and a small putter (an appliance for short distance haulage) require the supply from one common cable to be sub-divided by switch units to each sub-cable. A four-panel enclosed, flame-proof, three-phase board with switches and fuses, with bus-bars the entire length of the board, would be required for such a plant, but in some cases even larger boards are required below ground; the illustration (Fig. 98 on Plate XXI) shows a nine-panel board of this type constructed by Messrs. Mavor and Coulson, Limited, of Glasgow. The feeder cable comes to one end of the bus-bars, and branch circuits are tapped from the bus-bars through switches and fuses. Provision is made for taking armoured cable, and the gear is rendered safe to operate, being so constructed that the covers cannot be opened before the switches are closed, and the current cannot be switched on while the covers are open. The casing construction consists of heavy castings with broad, machined, flanged joints and relief valves fitted to prevent excessive internal air pressure.

In addition to the various machines, it has been found advantageous in some cases to instal a coal face lighting equipment, at present only made for non-fiery (naked light) mines, in which a single-phase transformer, protected by switch and fuses on the primary side, is connected to the main supply. This transformer reduces the voltage to 25 volts. The lamp fittings are of the detachable type, and plug into adaptors arranged for concentric cable wiring. Cable of the "cab" tyre type is used for this lighting equipment.

Messrs. Mavor and Coulson have on view in the Palace of Engineering, control equipment suited to large installations, and they exhibit three different types of controllers suitable for fiery mines. Each embodies a mechanical detent for preventing too rapid reversal. This consists of a mechanical interruptor, which involves a stop being made by the operator at the "off" position before the controller can be switched over to reverse. These controllers embody the usual special features in the casing to render them flame proof.

Some engineers now use an air-break controller on alternating current because it is cleanly and free from carbonisation of oil, and tests show that the contacts have a longer life. The resistances used with the controllers are of the stamped unbreakable grid type, built up on steel rods with mica insulation and enclosed in flame-proof or ventilated cases. The appliances comprised in the control unit, that is, the controller, the resistance, and the main switch, can either be separate or mounted together on an inverted channel-iron frame. In the latter case, all inter-connections are incorporated, and a terminal chamber is provided for the incoming mains and the outgoing cables to the motor. A controller of the oil-immersed type for 40 h.p., and of Messrs. Mavor and Coulson's manufacture, is shown in Fig. 99 on Plate XXI, coupled to a resistance for use with an A.C. motor, and is fitted with lever-operating gear.

A hand-wheel operated controller of the oil-immersed type for 120 h.p. by the same firm (Fig. 100) is also fitted with a mechanical detent. The case has an oil gauge, and provision is made for drainage. The gear is so arranged as to overcome the necessity for loose connections or cables. It is impossible to open or close the cover unless the controller is in the "off" position, which is ensured by a mechanical interlocking device. In all cases, glands may be fitted for taking all types of armoured cable.

The firm's pillar type of control gear for non-fiery mines (Fig. 101) comprises a main switch and fuses for direct-current circuits, and an oil switch with automatic trips for alternating current circuits. The pillar is complete with an air-break horizontal controller, and unbreakable resistances. All inter-connections are made and brought out to a terminal chamber mounted at the rear of the pillar and fitted with a protecting cover. Arrangements can be made for various types of armoured cable or pipes. Hinged sides are fitted to permit of easy inspection, and ammeters can be added if required. Flame-proof starting panels for direct-current motors consist of a cast-iron pedestal having mounted thereon a face-plate starter, fitted with overload and no-volt trips, and switch and fuse box or automatic circuit breaker to control the supply.

Messrs. Mavor and Coulson's three-phase alternating current rotor starter, of the flame-proof pattern, specially designed for installation in fiery mines, is shown in Figs. 102 and 103 on Plate XXI. It is of the oil-immersed type, fitted in a cast-iron tank, the cover of which has broad, machined, flanged joints and the usual excess pressure relief valves. The face-plate is mounted at the top of the tank, and ensures that the switch (Fig. 103) is operating in the upper and cleaner part of the oil. The contacts are removable without necessitating the lowering of the oil level, and may be inspected by merely removing the cover. A panel switchboard for a non-fiery mine, the switch and fuse units having packed joints, is also exhibited. In this type, a protective cover is fitted over the switch to prevent accidental contact when renewing the fuses. The switch and fuse units are fitted with a 45 deg. angle adaptors for the cable glands. This arrangement gives, with the same gland, four positions—upwards or backwards, inclined backwards and upwards to the left or to the right—this facilitates the approach of the cable and saves bends.

There is probably no part of the electrical equipment of a coal-cutting plant which fulfils such an important purpose as the gate-end box. Fig. 104 illustrates the Mavor and Coulson three-phase gate-end box, and shows the arrangement of the internal parts. The construction of the case is similar to that of the flame-proof switchgear, but in this instance both case and cover are heavily ribbed to ensure against damage that may be caused by falls of the roof or coal. The gear is mounted on mica-insulated steel rods and is of very robust construction. A special feature is the fitting of a terminal box for taking the supply cable which enables the gate-end box to be advanced by the insertion of a junction box without disturbing the filling of the existing armouring gland. The trailing cable is taken to the machine through a plug and socket known as a pommel. The interlocking is such that the pommel cannot be withdrawn nor the cover of the gate-end box opened unless the switch is in the "off" position. The gate-end box is manufactured either with feet as illustrated or mounted on skids.

Signalling equipment exhibited consists of a transformer enclosed in a flame-proof case, flame-proof bell pushes and bell pulls, and general signalling accessories. This apparatus is required where signalling from the main alternating current supply is intended to supersede the old accumulator battery system. The transformer is provided with tappings covering 5 to 25 volts by increases of 5 volts. The case is fitted with the usual cable glands and relief valve. The bell pushes and bell pulls are designed to be proof against accidental operation. Cable joint boxes are installed of neat and compact design, fitted with substantial clamping arrangements for the armoured cable and provided with connectors, mounted on an insulated bar, for joining up the conductors. Provision is made for compound filling, and the design is such that the joint box can be supported in the same manner as the cable, thus obviating the necessity of providing brick pillars.

The Diamond Coal Cutter Company, Limited, of Wakefield, exhibit a flame-proof, six-way, three-phase switch and fuseboard, arranged to control machines exhibited in the Palace of Engineering. All parts are extremely accessible, and the switch covers are so interlocked as to prevent their being opened while the switch is in the on position, and conversely, the current cannot be put on while the switch cover is open. Examples are also exhibited of this firm's oil-immersed switches, fitted with overload coils, and, where desired, also with no-volt coils. A three-phase junction box on similar lines to a standard gate-end box is also exhibited; it is fitted with a small bus-bar chamber, so that a branch may be tapped off the main cable, and a switch is embodied in the construction in accordance with the regulations. An oil-immersed form is also manufactured. A further useful accessory is shown in the trailing cable reel, fitted with flame-proof, totally enclosed slip rings for use at the coal face, an appliance which considerably increases the life of the trailing cable.

Coal-cutting machinery may be divided generally into three classes, according to the arrangement and drive of the actual cutters or picks. The first and oldest type is the disc cutter, a form of horizontal circular saw, capable of being drawn along the face, and so arranged that it cuts to a depth of more than half the diameter of the saw, a peculiarity that involves very special features of design. As the saw cuts in a horizontal plane, and the area of the saw covered by the coal that is being cut is of considerable dimensions, it follows that difficulties may be produced by want of flatness in the strata from which the coal is being won.

The second type of machine, known as the chain type, carries the cutters, secured in the links of a chain which passes over a pulley at the end of a jib; the width of this jib is much less than the width of the disc, and it is consequently possible to make the cut, and to support the coal that has been cut nearer to the actual cutting face than in the case of the disc machine. The chain form permits of another arrangement, the inversion of the head, so that the cutter can work at the top of the seam instead of at the bottom, a feature that is sometimes of importance. In its most recent developments, the chain cutter has found another use in driving headings in coal, the cutter being then arranged in the form known as the Arcwall cutter.

The third type of coal cutter is the bar. It is a machine that has been very highly developed in recent years, and is so made that it can work under conditions in which either the disc or chain would be at a disadvantage. The bar machine consists of a long taper bar pierced with holes, in which cutters are secured so as to cover effectively the working length. In the Universal type of machine, the bar can be swivelled about a vertical axis in the body of the machine, the lower part of the gear head being somewhat similar to that of the chain type, and known as the "banjo" in both cases.

In the evolution of machines of these classes, a great step has been made towards standardisation by arranging the cutting portions of the machine as separate units from the driving portions, the two sets of units being connected together so as to form one complete machine. The introduction of electric power to coal cutting, supplanting the use of compressed air in many cases, has led to the further development of making the driving portions of the machine of the same external form, and interchangeable with each other in the drive and in the connection to the cutter mechanism. It is in fact, possible in this way to substitute a Universal bar head for a chain head on the same driving gear.

Yet another variety of coal-cutter is afforded by the percussive type, mounted on a vertical pillar, and capable of being traversed about the axis of the pillar at any desired height; or in some cases, by the addition of a second worm quadrant having its axis at right angles to the pillar, vertical cuts can be made as well as horizontal, which may be of a great advantage in driving headings.

A brief mention has previously been made in

ENGINEERING, of May 25, 1923 (vol. cxv, on pages 649-50, with an illustration on page 656), of the Samson disc coal-cutter. The first disc coal-cutter, made by Messrs. Mavor and Coulson, was constructed some fourteen years ago, and the design of the type has been steadily improved through the succeeding years. The machine consists essentially of three main components; the motor, the gear-case, comprising the haulage gear and the controller box, and the jib bracket and jib which support the disc wheel.

The driving of a disc coal-cutter by means of an electric motor, is a problem that has presented some difficulty on account of the severity of the service. The necessity for complete enclosure and the restriction of dimensions, particularly in height, require the sacrifice of the normal characteristics of an electric motor, and the machine must necessarily embody compromises between the desirable and the obtainable. The main difficulty is to provide the maximum power within the given limit of height, and most of the troubles in the past with the electric motors of disc machines have been due to conceding too much to the limitation of height, and thereby sacrificing the space necessary for safety and reliability in the windings and their insulation. A special feature of the Samson disc machine is the flat floor of the motor casing, and the large space between the coils and the floor for lodgment and drainage of oil that may gain access to the motor casing.

The standard three-phase disc machines have motors of the slip-ring type, with controller and starting resistances. Though it would be possible to use squirrel-cage motors for disc machines, they would involve complication in the driving gear, because they cannot be relied upon to give adequate starting torque under all conditions of service. Proper mechanical provision is made in the motor to secure rigidity in the windings when subjected to vibration, and to avoid relative movements which might cause abrasion of the insulation. In the case of air-driven machines, the air turbine motor is identical with that described on pages 649-650, and illustrated on page 656 of the article quoted above.

Although the disc coal-cutter is still manufactured, it is to-day far outnumbered by the other types, which have certain advantages over it. In the chain-type coal-cutter, for instance, as manufactured by the Diamond Coal Cutter Co., the distance from the solid coal to the point at which a wedge can be driven to support the coal, is less than 2 ft. as against several feet in the case of the disc-cutter, with the result that the risk of coal or overlying strata breaking up and falling on to the cutter wheel and its support, thereby causing stoppages, is diminished. In the chain-type machine, the cutter picks are fixed into a flexible chain that runs in fixed runners round a jib or cutter arm, enabling the distance over the cutting points to be reduced to less than 24 in. in the direction in which the cut is taken. The placing of sprags can consequently be effected at this distance from the solid coal with increase of safety where the roof is not sound.

In the early designs of the Diamond chain-type coal cutter, the jib was fixed in the centre of the machine, so as to make it suitable for cutting in either direction, and this required the cutting away by hand of a "stable" at each end of the face similar to those required for the disc machine. It was subsequently found an improvement to design the machine so that the jib was placed at the end, where the cutting chain was more accessible to the operator and gave facilities as mentioned above for fixing the sprags and props close up to the cutters. A further advantage in placing the jib at the end of the machine is that it is possible to provide means for slewing the jib into and out of the cut by power. The jib is also made to slew to either side of the machine, so as to suit either a right or left hand coal face. This arrangement also affords greater facility for converting the machine from the under-cut to the overcut type by fitting a different gearcase to the driving mechanism of the machine, this, together with the hauling or travelling mechanism, remaining unaltered.

In normal work, the machine cuts on the floor level, but sledges can be provided when it is required to cut above the floor level. The design of this type of coal-cutter is such that it can be fitted with either a compressed air turbine motor as shown in Fig. 105 on Plate XXII, or an electric motor, using either direct or alternating current. The hauling gear and the cutting chain portions of the machine are interchangeable independently of the drive. The hauling of the machine along the face can be effected by either of two types of traction, rope or chain; the latter is shown in the illustration and is arranged to work at either side of the machine. In practice, it is usual to set the cutting chain jib slightly forward, so that the machine draws itself in to the coal face when cutting, and thus does not tend to kick out when cutting, and displace props. This is an advantage where the roof is tender and it increases safety in working.

The reduction gears from the driving mechanism to the hauling chain sprocket are contained in a totally enclosed steel gearcase, forming a reservoir to which the oil is returned after circulation to all parts by means of an oil pump. All the gear wheels are steel, machine cut and case hardened, and wherever possible they are mounted on squared or castellated shafts so as to avoid the use of loose keys. These shafts are of high carbon steel ground to size, running in bronze bearings for low speeds, or in roller bearings for high speeds. The chain hauling drive is arranged through a friction clutch which can be set to slip at any desired pull, and

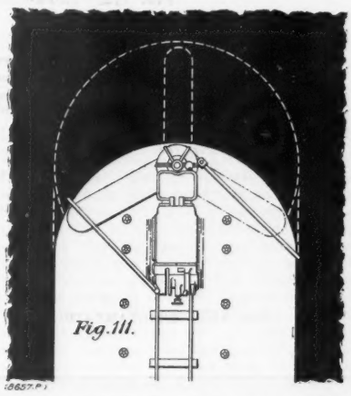


FIG. 111. DIAGRAMMATIC PLAN OF ARCWALL WORKING.

act as a safety device in the event of the machine getting jammed whilst cutting. Two haulage speeds are provided for hauling the machine light, at fast speed along the face for flitting, and at slow speed for jibbing in or cutting along the face. Change gears are provided for the feed, to suit the nature of the material being cut. In the rope haulage, however, a wide range of speed is embodied in the design, together with a high flitting speed of about 30 ft. per minute.

A feature of the machine is the method of mounting the shafts, enabling the machine to be run with the top covers removed, and permitting the examination and testing of the driving gear, whilst running, and readily permitting also the setting of the friction clutch for the desired load. The arrangement has the further advantage of providing rigidly fixed bearings for the shafts, independent of the top covers. A hardened steel clutch, operated by a handle outside the gearcase, is fitted on the main driving shaft for disengaging the cutting chain sprocket when desired—for example, when moving the machine into position or for flitting.

The jib is provided with a bearing on each side of the cutting chain sprocket, and can be readily adjusted for tightening or slackening the cutting chain, and is fitted with hardened steel guide runners, for the cutting chain, which can be readily replaced. A locking pin is fitted to secure the jib in the central position when flitting, and the same pin secures the jib at either side of the machine in the working position. The cutting chain can be adjusted without withdrawing the jib from the cut. The cutters are of simple design, easy to forge, and secured in position by means of screws, which can be fixed in the box-links on either side. Three different angles of box-link are generally used, giving a five-position chain, so that with the same type of cutter pick a width of cut is obtained which gives ample clearance for the jib.

The machine illustrated is fitted with a compressed-air turbine of approximately 40 h.p. at 50 lb. per square inch pressure. Its electric counterpart has, for alternating current, a squirrel cage motor of the totally-enclosed flame-proof type, capable of standing overload for a long period, whilst the direct-current motor is compound wound with interpoles. The rotors are mounted on heavy roller bearings, and great care has been taken in designing the housings for the bearings to prevent leakage of oil from the machine gear-cases to the motor. The controlling switches have contacts fitted, which on test have successfully stood up to 40,000 operations under full load conditions, whilst mica or similar insulation is adopted throughout. The cable pommel for attaching to the trailing cable is interlocked with the barrel, so that it cannot be entered or withdrawn except when the barrel is in the off position. The starter is of the star-delta type, fitted with a reversing type barrel, whilst the direct current is a similar switch of the controller type.

The Arcwall method of working a coal seam probably owes its development to the use of the Universal bar type of machine, but the chain type has been adapted to this work with great success, and a machine of this type, of Messrs. Mavor and Coulson's manufacture, is shown in Fig. 106 on Plate XXII. In work, the Arcwall coal-cutter is generally carried on wheels and run forward on a track laid in the centre of the working, and never leaves the rail track. It is run to the face of the heading, and with the machine in place on the rails, the jib is slewed round to undercut the coal in an arc. The width of the cut, if taken through the full sweep of the jib, 180 deg., depends upon the length of the jib (Fig. 111, on this page). Where it is desired to drive a heading narrower than the diameter of the circle swept by the jib, the rails should be laid on one side, and the jib sumped into the coal along the rib side at the required angle, while the machine travels at its cutting speed along the rails. When the full depth is obtained, the jib is slewed round till the full width is obtained, when the slewing is stopped, and the machine cuts out, leaving the cut of the desired width.

This method has the advantage that in cases of bad roof, no timber at the face need be disturbed to allow the coal-cutter to work the undercut. For this work, the track requires to be well laid, of heavy section rails, with carefully-designed curves. The limitations of the machine are that the cut cannot be made on the natural floor of the seam. With 10-in. wheels, the height from the top of the rail to the bottom of the cut is 8 in., thus, allowing for the thickness of rail and sleeper, the height from the floor to the bottom of the picks is some 13 in. or 14 in.

The Universal bar type of coal-cutter, made by Messrs. Mavor and Coulson, and based on twenty-five years' experience of the application of coal-cutters, has achieved great success by its suitability equally for long wall, short wall, and heading service. Not only can the banjo revolve round a vertical axis, enabling the bar to perform work similar to that done by the general type of cutter, but the head carrying the banjo can also be tilted in a plane at right angles to the length of the machine, thus giving an inclination to the plane of action of the cutter bar. This machine has been so fully described in ENGINEERING of May 18 and 25, 1923 (vol. cxv, pages 614-616 and 648-649), that further notice here is unnecessary.

The Siskol coal-cutter or heading machine, (Fig. 107, Plate XXII), constructed by International Channelling Machines, Limited, consists of a percussive machine carrying a drill and supported on the bar by a head carrying a sector of a worm wheel, into which gears a hand-driven worm. This enables the drill to be traversed across the face in a plane at right angles to the stretcher bar. A base is fixed to the machine, under which chocks can be placed to lift the wheels off the floor. The later model, called the Siskol scalloping machine, is fitted with two worm sectors, enabling the cutting point to be

traversed at will in either of two planes at right angles to each other. By means of this arrangement, it is possible to put in a horizontal cut about the middle of the seam, and a sheer or vertical cut through it if necessary; then, exchanging the five-pronged cutting bit for a pick with a single point, and directing this to any desired point at the face of the heading, and feeding the tool forward, the coal can be broken out in lumps without the use of explosives.

Conveyors for removing the coal from the workings may be divided generally into three classes: (1) the belt conveyor running continuously and discharging the coal at the end into tubs or on to another conveyor running at any desired angle; (2) the shaker or jigger conveyor, driven by an electric or compressed air motor which may be coupled to the shaker either directly by a bar or by a rope, the latter arrangement being used where there is a sufficient gradient to ensure a gravity return; (3) another form of conveyor is the creeper, or scraper, of which the gate-end loader is an example. In this case, the coal is received from another conveyor and raised to a sufficient height to drop into the tubs which are successively placed under its loading end.

An example of an electrically driven coal-face belt conveyor is that installed by the Mining Engineering Company, Limited. This conveyor comprises a steel-plate conveyor-head on which are mounted three drums, two of which are driven and one an idler. These drums are mounted on solid shafts running on ball bearings, driven through a gearbox containing the reduction gear and attached to the head. The drive is of the balanced worm type (eliminating end thrust) arranged with two sets of spur reduction gears. The variations in the load on the driving drums are equalised by means of two small pinions fitted at the bottom of the gearbox. The worm shaft is connected by a flexible coupling to a 7½ h.p. flame-proof motor running at 750 r.p.m., and controlled by a reversing drum type controller, mounted on the conveyor head. The belting used is 20 in. wide, of solid woven cotton, with hardened surfaces and edges. It is made up in 25 yd. lengths and coupled with Meco belt fasteners specially designed to avoid breakage at the joints. Light roller frames constructed of steel framework with wooden rollers 5 in. in diameter, are used at intervals of 6 ft. to 7 ft. At the far end of the conveyor, the belting is carried over a drum, to which tension is applied by means of a sylvester, or by tension screws, attached to the pit props.

The conveyor in the mine has a capacity of 50 tons per hour. The advantages claimed for this type are that only four brake horse-power is required to run 200 yd. of belting. The gears are totally enclosed and run in an oil bath, so that the machine works practically noiselessly, and the coal can be carried on any inclination not exceeding 1 in 4, up and down and over floor undulations, without interfering with the output. The machine is also sufficiently light to enable it to be moved from place to place by a gang of two or three men in a few hours. An arrangement is provided to keep the belt clear from small coal, by removing it at the tension end, so as to obviate caking under the drum and damage to the belt. This has been done by means of a rotary brush set at an angle to the belt and positively driven by means of an enclosed skew gear attached to the tension drum shaft, so that the brush rotates in the opposite direction to the movement of the belt. A deflector plough fitted in front of the brush throws off large pieces of coal, and the brush itself clears the small material from the belt.

A shaker conveyor has been installed in the colliery on No. 5 face by Messrs. Mavor and Coulson, for working under conditions in which it would be inconvenient to accommodate a rope transmission in the roadway. It comprises a low-type driving gear (Fig. 108, Plate XXII), which can be accommodated within the height of the 2 ft. seam, and is coupled direct to the conveyor trough. The arrangement is shown diagrammatically in Fig. 109 on Plate XXII. The direct-coupled driving gear is electrically driven through double reduction gear, the pinion on the motor shaft being of the silent type, and the other gears machine-cut from mild steel forgings. The connecting rod, driven from a pin on the second reduction gear, engages with the lower pin in the rocking arm, and is forked to receive the coupling rod, which can be attached either by this pin to give the maximum stroke of 9 in. or can be driven through the upper pin, giving a stroke of only 5 in., the latter being used for steep inclinations and the former for low inclinations or flat seams.

A larger and more powerful gear, Fig. 112 above, exhibited in the Palace of Engineering, is of similar construction, but arranged with a rope drive and three changes of position for the pin engaging the rope shackle with the rocking lever. The shortest stroke is 6 in., and the alternative longer strokes are about 9 in. and 12 in., respectively. This type of driving gear is frequently placed in a road adjacent to the conveyor, and operates through a quadrant or bell-crank, shown diagrammatically in Fig. 113 above, carried on an adjustable swivel prop. By this arrangement, the driving gear may remain stationary for two or three weeks, the rope being extended as the face advances. For operating on the level, or with suitable material against low gradients, a spear connecting rod of pitch pine may be used instead of the wire rope, to connect with the quadrant, the direction of running of the motor being reversed or the link inverted, and the trough pushed against the direction of delivery. With this arrangement, it is found that loose material will travel quite easily against low gradients. The shaker type of conveyor can be readily shifted from

COLLIERY APPLIANCES; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. MAVOR AND COULSON, LIMITED, GLASGOW.

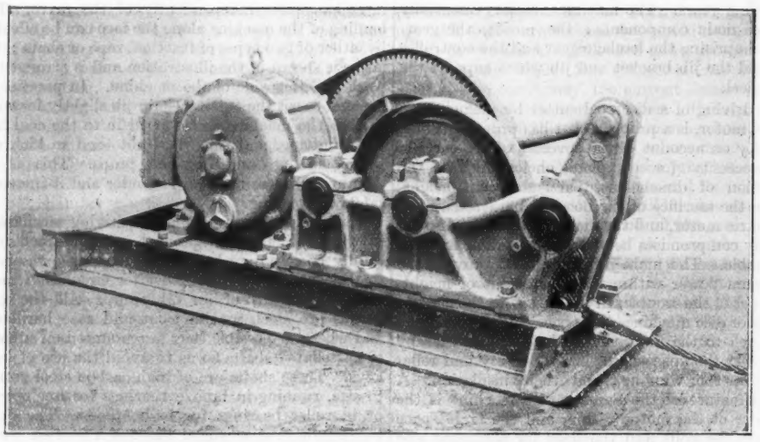


Fig. 112. Rope-Coupled Shaker Conveyor.

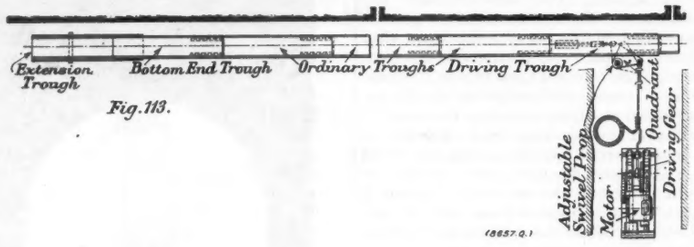


Fig. 113 Diagrammatic Plan of Rope-Coupled Shaker Conveyor

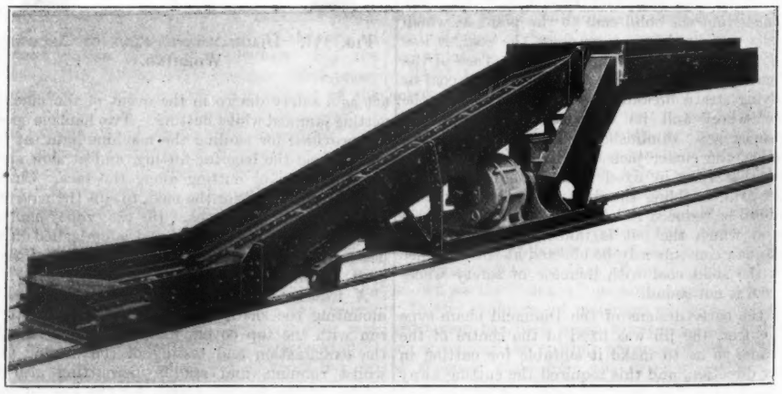


Fig. 114. Gate-End Loader.

AUTOMATIC TRACTION SUB-STATION GEAR.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LTD., ENGINEERS, RUGBY.

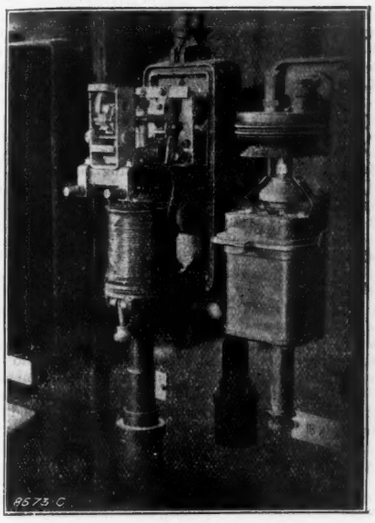


FIG. 1. REPEAT-ACTION RELAY AND TIME-DELAY RELAY.

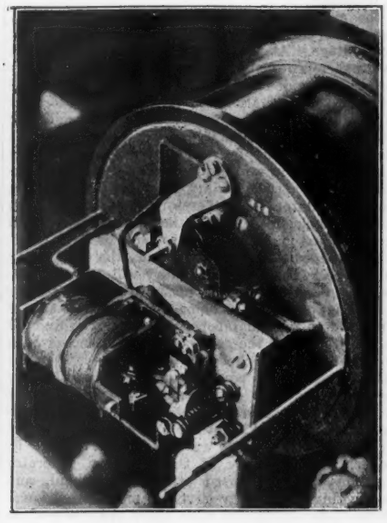


FIG. 2. MACHINE TEMPERATURE RELAY.

one place to another, the trays being light and easy to handle.

A different pattern of shaker or jigging conveyor is that made by the Diamond Coal Cutter Company, of Wakefield, illustrated in Fig. 110, on Plate XXII. The conveyor itself, in this case, consists of a plain trough made in 9 ft. or 10 ft. lengths and jointed in a simple manner. The troughs are mounted on rollers which run on cradles designed to grip the floor, keeping their position when the conveyor is working, but easily removable sideways when the conveyor is being moved to a new position. Four sizes of troughing are made and used according to requirements of delivery. The conveyors may be driven either by electric driving gear, as in the previously described examples, or by a compressed-air engine, one type of which is shown in the illustration. The conveyor engine is single acting, pulling the troughing quickly up the gradient of the cradles, and causing the coal to slide forward, the troughing falling by gravity on the return stroke, and thus bringing the piston back to its starting position. The conveyor engine is readily adjusted for position by means of a chain and sylvester prop withdrawer, whilst stay props prevent the engine from turning or getting out of position. The special feature of these engines is the remarkably low air consumption per ton of coal conveyed, as proved by repeated tests at the coal face.

A third variety of conveyor is the gate-end loader, of the scraper or creeper type, one of which has been installed by Messrs. Mavor and Coulson at the end of No. 5 face in the colliery. It serves to receive the coal from the shaker or belt conveyor, and to elevate and load it into tubs successively placed under its end. This machine, of crocodile shape, is illustrated in Fig. 114 on page 226, and carries the coal by an endless creeper chain up the inclined portion of the loader to a horizontal length projecting over the tubs into which the coal is to be discharged. The machine is carried permanently on wheels and remains on the rails, a switch being arranged in the track under the upper horizontal projecting length, so that the empty tubs may be brought from the end of the side road and filled and placed successively in the train of full tubs accumulating on the road that leads from the loader. The advantages claimed for this form of loader are that floor ripping is unnecessary, and the preferable roof ripping can be employed instead. Also, it is unnecessary to drive an advance heading in the solid coal at the end of the loading road.

(To be continued.)

AUTOMATIC SUB-STATION FOR THE HENDON-EDGWARE EXTENSION RAILWAY.

ONE of the most interesting features of the extension of the London Electric Railway from Hendon to Edgware, which opens for traffic on Monday next, is the sub-station which supplies electric power for operating the trains. This sub-station is unique in being not only the largest automatic sub-station in Great Britain, but also the first to be installed for electric traction purposes. The sub-station building has been designed to accommodate three 1,200-kw. rotary converters with their control gear and accessories, and at the present time two equipments are in operation. The complete plant has been designed, manufactured and installed by the British Thomson-Houston Company, Limited, of Rugby, with the exception of the main and auxiliary transformers; the former were supplied by the Metropolitan-Vickers Electrical Company, Limited, and the latter by the Brush Electrical Engineering Company, Limited. We illustrate some of the plant installed in this sub-station in Figs. 1 to 4 above and on page 230.

Before proceeding to a detailed description of the plant and its method of operation, a general outline of the scheme will be of interest. A three-phase high-tension supply at 10,500 volts, 33⅓ cycles, is provided from the company's power station at Lots Road, Chelsea, to the new sub-station, which is situated at Burnt Oak, about one mile from the Edgware terminus and four miles from the nearest manually operated sub-station, situated at Golders Green. The high-tension supply reaches Burnt Oak sub-station by means of two three-core cables from Golders Green sub-station, where control is effected by manually-operated oil circuit-breakers. The only high-tension switchgear at Burnt Oak consists of change-over isolating switches so arranged that, for normal operation, each rotary is connected to a separate feeder. Upon the closing of a feeder oil circuit-breaker at Golders Green, the rotary to which it is connected at Burnt Oak starts up automatically and takes load, subsequently being entirely under the control of the automatic gear.

Five brick and stone cubicles of the London Electric Railway Company's standard type are provided to house the high-tension 'bus-bars, to which the two incoming feeders are connected through single-pole isolating switches. The 'bus-bars are in two sections, change-over isolating switches being provided between the two sections, and between the 'bus-bars and the transformers, so that either rotary can be operated from either feeder, or, in the event of a breakdown on one feeder, both machines can be operated from the sound feeder. The high-tension cell-work occupies a central position at one end of the building, and immediately in front of it are mounted the main transformers. These consist of two three-phase banks, each comprising three 440-k.va., single-phase, air-blast transformers, delta connected on the high-tension side and double-delta on the low-tension side. Cooling air for each bank is supplied by a centrifugal blower through a duct formed in the transformer foundations. The squirrel-cage induction motor driving this blower also drives the small auxiliary generator which is used to fix the polarity of the rotary at starting. A small single-phase transformer mounted on the floor adjacent to the blower set gives a low-tension alternating-current supply for the control circuits, and this, together with the blower motor, is connected direct to the low-tension side of the main transformers.

In front of each bank of transformers is the automatic starting panel. This is of polished slate with angle iron supports, and carries, in addition to the starting and running contactors, three small contactors for controlling the fields of the rotary and auxiliary generator. Each rotary converter, one of which is shown in Fig. 4 on page 230, is rated at 1,200 kw., 500 r.p.m., 600–630 volts, is compound wound and equipped with a self-synchronising starting motor and over-speed device. It differs from a manually-operated machine in being provided with an auxiliary field winding to determine the polarity, and arranged with protection against bearing overheating, starting motor overheating, and earth leakage. The bearings are fitted with flood lubrication in addition to the usual oil rings, the oil being supplied to the bearings from a storage tank in the basement by a small gear-type pump driven by a squirrel-cage induction motor connected in parallel with the blower motor.

The direct-current switch-gear, shown in Fig. 3, comprises two machine panels and a feeder board with their accessories. All the panels are of polished slate mounted on angle iron. Each machine panel carries an ammeter, voltmeter, reactive volt-ampere indicator, alternating-current and direct-current watt-hour meters, the relays required for controlling and protecting the machine, and standard lever-type isolating switches. A multiple change-over switch and three small control switches are also provided to enable the machine to be operated manually if desired. The feeder board controls four circuits, and, in view of the fact that an insulated return rail is used, circuit breakers are provided on both poles. All direct-current circuit breakers are of the high-speed type, and are in general mounted on the floor behind the panels. Their design was illustrated and described in an article appearing on page 13 of our issue of July 4 last. In the case of the feeder board, a gallery is provided to carry some of the breakers. A general view of the direct-current switch gear is given in Fig. 3, and the arrangement of the feeder board can be clearly seen from Fig. 4.

When it is required to start up a rotary converter at Burnt Oak, the attendant at Golders Green closes the appropriate high-tension feeder circuit-breaker, thus giving a high-tension supply to Burnt Oak. This energises the main transformers, which, in turn, energise the control transformer, the blower motor and the oil-pump motor. The two latter machines start up, but before any further operations can take place, the auxiliary generator attached to the blower motor must build up its voltage. As soon as this happens (indicating that the blower is up to speed and the transformers are receiving a supply of cooling air) the rotary may take load. Providing that the master controller, which is mounted behind the direct-current panel, is in the "off" position, a master-control contactor now closes. Should the master controller not be in the "off" position, it must first run to this position before the contactor can close, thus ensuring that the complete sequence of switching operations must be gone through at each start.

In order to attain this, the master-control contactor is fitted with a normally-closed contact which provides a circuit for the controller motor when the contactor is open. On reaching the "off" position, the controller stops automatically and waits for the contactor to close. The closing of the master-control contactor makes alive the control 'bus-bars and sets in motion the motor-operated master controller. The first action performed by the latter is to close the starting contactor, thus connecting the starting motor to the transformer, and the rotary converter then starts up. At the same time, the auxiliary field winding on the rotary is connected to the auxiliary generator, thus ensuring that the machine will build up the correct polarity, and the main field winding is connected to a tapping on the field rheostat, so as to give the correct field strength for synchronising. At this point, the controller stops and waits for the machine to synchronise. When the rotary is in synchronism, the controller is retarded by a synchronous-speed indicating relay and closes the running contactors, thus short-circuiting the starting motor and connecting the converter direct to the transformer. The controller, continuing its travel, next opens the starting contactor, changes over the main field of the rotary from the tapping previously mentioned to the field rheostat arm, and

disconnects the auxiliary field winding from the auxiliary generator. The field rheostat arm is left normally in the position which gives full voltage on the rotary, but provides a means for raising or lowering the machine voltage, should occasion arise.

It will be noted that the machine is not yet connected to the direct-current 'bus-bars, so that there is no possibility of the polarity of the auxiliary generator being reversed by short circuits or heavy overloads which may react on the auxiliary field winding of the rotary. Further motion of the controller closes the machine-line contactor and high-speed circuit-breaker, and the rotary then picks up its load. At this point, the controller again stops and remains stationary as long as the rotary is in operation.

The feeder-breakers close automatically as soon as the 'bus-bars are energised, but as it may sometimes be desirable to feed through the sub-station to the Burnt Oak Edgware section of the track without running up a rotary at Burnt Oak, the two-feeder circuit-breakers supplying the Burnt Oak Golders Green section are arranged to close either from track voltage or 'bus-bar voltage, whichever appears first. Once these two breakers are closed, the Burnt Oak 'bus-bars are, of course, made alive through them, and, the remaining circuit-breakers close automatically from the 'bus-bar voltage. To shut down the machine, the high-tension feeder circuit-breaker at Golders Green is opened. This de-energises the main transformers, with the result that the master-control contactor opens and the machine shuts down, the master-controller returning automatically to the "off" position in readiness for the next start up.

Protection is afforded to the machines against practically all contingencies by the automatic devices explained below. On overload or short-circuit, the high-speed circuit-breaker opens, inserting a resistance in the machine circuit, and by means of an interlock, opens the line contactor, thus disconnecting the rotary from the 'bus-bars. After a short interval, the line contactor and high-speed circuit-breakers close again. If the fault has disappeared, normal operation is resumed, but, if the short-circuit persists, the sequence is repeated until, after a predetermined number of operations, the breaker is locked open pending the investigation and removal of the fault. Similar protection is provided for each track feeder, except that the resistance is omitted and that the breakers can be re-set electrically from Golders Green after locking out. The track circuit-breakers are adjusted for three operations and the machine-breakers for four. With this adjustment, a fault on a feeder which trips both the feeder-breaker and the machine-breaker will lock out the feeder-breaker on the third operation, after which the machine is free to be reconnected to the 'bus-bars to supply the remaining sound feeder. A part of the machine relay panel, showing the repeat-action relay and time-delay relay, controlling the machine high-speed circuit-breaker, is shown in Fig. 1 on page 227.

An over-speed device fitted to the shaft of the rotary converter opens its contacts if the machine attains a speed greater than that for which the device is adjusted. The operation of the device de-energises the master-control contactor and shuts down the equipment, which cannot restart until an inspector has visited the sub-station to reset the device. If the alternating-current voltage should be below a pre-determined value when the oil circuit-breaker at Golders Green is closed, an under-voltage relay fails to close its contacts and the machine will not start up. If the voltage falls off while the machine is running, this relay opens its contacts and the equipment will shut down after a pre-determined time interval. The object of this time-delay is to prevent the machine from shutting down due to momentary fluctuations of the supply voltage. As soon as normal voltage is restored, the under-voltage relay again closes its contacts and the equipment starts up, reconnecting the machine to the direct-current 'bus-bars. It should also be mentioned that unless all three phases of the incoming high-tension line are energised, it is impossible for the equipment to start up. Should the equipment, through any cause whatever, fail to complete its sequence within a pre-determined time, a sequence-timing relay will operate and shut down the plant. This relay must be reset, and it is therefore necessary for an inspector to visit the sub-station, ascertain and remove the cause of the trouble, and reset the relay before the machine can again be put into operation.

Each rotary converter is protected against over-heating by means of a machine-temperature relay, illustrated in Fig. 2, and designed to have the same heating and cooling characteristics as the rotary converter. If a given overload be maintained for a longer period than that for which the machine is designed, this relay will de-energise the master-control contactor, thus shutting down the plant. As soon as the machine has cooled to a safe temperature, the relay automatically resets itself and the equipment starts up. A temperature relay is also located in the exhaust opening of each transformer, and in the event of the temperature of the exhaust air attaining the value for which the relay is set, the equipment is shut down and cannot restart until the trouble has been investigated and the relay reset manually.

If the auxiliary generator fails, the machine line-contactor and high-speed circuit-breaker will open, due to low voltage. At the same time, the direct-current low-voltage relay opens its contacts and shuts down the machine by de-energising the master-control contactor. In this case also, the machine cannot re-start until the station has been visited and the cause of the trouble removed. Should the blower motor fail, thus cutting off the air supply from the transformers, there will be no direct-current supply available for the control circuits, since the auxiliary generator is also driven by the same motor. It is therefore impossible to have a load on the transformers when the blower is shut down. If the machine should flash over to earth or if the windings should break down to the frame, the earth relay fitted to the bed plate of the rotary will open its contacts, thus de-energising the master-control contactor and shutting down the machine. This relay is also of the hand-reset type and consequently the equipment cannot restart until the cause of the trouble has been removed and the relay reset by hand.

It has already been pointed out that the auxiliary generator is entirely disconnected from the rotary converter before the latter is connected to the direct-current 'bus-bars, and it is therefore impossible for the rotary to build up with wrong polarity. There is, however, the possibility of the auxiliary generator connections being reversed after an overhaul, and although this contingency is very remote, provision is made for it by a polarised relay which must be excited in the right direction before the machine can be connected to the direct-current 'bus-bars. Each bearing of the rotary converter is fitted with a thermostat, which, in the event of a bearing overheating, will open its contacts, thus de-energising the master-control contactors and shutting down the machine. After a shut down due to this cause, it is necessary for an inspector to visit the sub-station and correct the trouble before the equipment can restart. In the event of the overheating of the starting motor, due to too frequent starting or failure of the machine to synchronise properly, temperature relays embedded in the windings will shut down the equipment in exactly the same manner as those fitted to the bearings. An extremely sensitive reverse-power relay is provided which will shut down the plant in the event of the rotary attempting to run inverted. This relay is self-resetting, and the machine will therefore restart immediately the relay has reset itself.

In conclusion, we may remark that, although the automatic sub-station described above is the first to be employed in traction work in this country, a considerable number of them are already in use for this purpose in the United States, where the prevailing conditions are generally more favourable for their employment. There is no doubt, however, that the use of automatic substations will extend in this country, both for traction work and for other applications, and, for this reason, the results obtained in practice with the installation at Burnt Oak will be watched with more than usual interest.

Bridge Built in 30 Hours.—In the short time of 30 hours a condemned bridge spanning the four-line track of the London Midland and Scottish Railway just south of Boxmoor was demolished and a new bridge erected. The work comprised the removal of the roadway from the top of the old bridge, the removal and loading up of the old bridge, the erection of the new bridge, and the relaying of the roadway over the new bridge. All work was accomplished without interfering with the regular train service.

Contracts.—Messrs. Siemens Brothers and Co., Limited, of Woolwich, have secured contracts for the manufacture and laying of some 3,200 miles of submarine telegraph cable to connect the Cape Verde Islands with Rio de Janeiro touching at the Island of Fernando Noronha, off the northern coast of Brazil. The first section is to be completed by the end of January, 1925, and the whole scheme should be in working order by the end of May, 1925.—We learn that the British Vacuum Cleaner Company, Limited, of Parsons Green-lane, London, S.W.6 have received orders both from the London Midland and Scottish Railway Company, Derby, and the Nottingham Corporation Electricity Supply Department for supplying their boiler-flue cleaning installation.—The Yarrow patent type of water-tube boiler has been selected by the Municipality of Rotterdam for the extension they are making to their electric power station. The boilers will be built by Messrs. Yarrow's licensees, the Koninklijke Maatschappij de Schelde, Flushing, who are building Yarrow boilers for other Dutch power stations. Messrs. Yarrow supply the boiler plates pressed to shape. The boilers are of Messrs. Yarrow's latest type, with Yarrow air heater and steam superheater. One of the boilers will be fired with pulverised fuel.

THE GERMAN IRON AND STEEL TRADES.

We learn from the Department of Overseas Trade that in Germany, during the week ending August 8, the iron market was very dull and only during the last few days were there any signs of improvement. Orders then slightly increased, but, on the whole, employment at the works remained insufficient and reports as to the closing down of works were increasing. Various departments of the Phœnix at Hoerde were to be closed down, while employment at the various works varied considerably. In general, orders on hand would hardly suffice for three weeks. Moreover, conditions, and particularly those concerning prices, were in such a state of confusion that manufacturers had to exercise the greatest precaution in accepting new orders. In fact, it was noticeable that there was little inclination to do so, in spite of the great need of employment. Prices dropped still further during the last few days.

The scrap market both in the Occupied and Unoccupied Territories, was dull. Owing to work restrictions, the works of Occupied Territory had almost ceased to buy, and only occasionally did one hear of a small contract on the basis of 50 mks. for steel scrap, free works, being concluded. No quotations were given for the inferior qualities of scrap, such as filings, sheet scrap, &c., which indicated that no business was being done, these conditions being common to Central Germany and Upper Silesia. The purchasing organisations of the works had almost suspended their activities. The North German scrap market was also stagnant, heavy scrap being quoted at 35–39 mks. per ton.

At the recent general meeting of the Phœnix A.G. fuer Bergbau und Huettenbetrieb at Duesseldorf, Director-General Dr. Fahrenhorst discussed the economic position, and stated that the present position of the heavy industry was one of extreme difficulty. Germany was in the midst of the symptoms of the deflation crisis which was making itself acutely apparent in a shortage of capital and credit. The consequences were a general disinclination for business, an insufficiency of running orders, and the holding back of new orders. The orders on hand at the works were thus constantly diminishing, and owing to the increase in the costs of production, caused by the decreased employment, coupled with the unfavourable prices on the inland and export market, steel production could only be carried on at a direct loss. It was necessary, therefore, to decide upon the closing down of some of their works. Owing to the geographical position, their Ruhrort department would, as far as possible, be kept fully employed, but their Hoerder Verein department would be chiefly affected by the closing down of works. Under these conditions it was only natural that the works of the concerns in the whole of Occupied Territory at present required financial assistance for which the restricted Reichsbank credit was insufficient and which would require to be covered by other credits. All manufacturing works were experiencing the difficulty that they had to use their credits for the greater part for their customers, who declared that unless they were granted a respite they were not in a position either to place orders or to accept goods. So far, the Phœnix had always succeeded in obtaining credits and they had been able to use a part of their Dutch credit of 10 million florins, obtained last year by the increase of their share capital by 300 million marks and by depositing these shares in Dutch hands, for the construction of new buildings, which were urgently required. But the burden on the works caused by the interest on these credits was extremely great and coupled with the increase of the costs of production, rendered competition on the world market very difficult. Further drawbacks were the export duties from Occupied Territory and the high freight, and, above all, the Micum burden, which burden was at least equal to the former net profit in good business years. Nothing definite could be said of future prospects in view of the uncertain conditions prevailing. Everything would depend upon the issue of the London conference. Dr. Fahrenhorst then went on to say that an essential factor for Germany's recovery was that particular interests should be put aside and that the heavy industry should join together in associations to ensure the most economic working and to form a basis for co-operation with similar industries abroad.

University of Bristol.—A prospectus of the Faculty of Engineering, which is provided and maintained by the Society of Merchant Venturers in the Merchant Venturers' Technical College, Bristol, has just reached us. Courses of study are available at the College for persons intending to engage in civil, mechanical, electrical, or automobile engineering, and particulars of these courses are given in the prospectus. The ordinances and regulations relating to degrees and diplomas in engineering subjects are included, together with particulars of the Bristol sandwich system of training engineers. The prospectus can be obtained from the Registrar of the Merchant Venturers' Technical College, Bristol.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Steel Output.—According to the figures just published the output of steel from Sheffield for June was 74,600 tons, showing a falling off of 35,400 tons, as compared with the output of May, and a decline of 25,400 tons as compared with the corresponding period last year. Of the total 38,200 tons were basic steel, 27,200 tons acid steel and 3,600 tons Bessemer steel. A similar state of affairs was experienced in Lincolnshire, where the output was 34,800 tons, as compared with 42,500 tons in May, and 50,000 tons in June last year.

Iron and Steel.—While the iron and steel trades of South Yorkshire show slight signs of revival, the immediate outlook is one of uncertainty. Inquiries on the whole are more numerous, but the amount of actual business passing is very limited, and prospective buyers are inclined to withhold purchases until the disturbing elements in political and international affairs are satisfactorily settled. The agreement with Russia was received in Sheffield with a certain amount of hostility, for local trade organisers are of the opinion that the amount of trade we should obtain from that direction would not be of the value to warrant a loan. With a falling-off in competition from Germany and other Continental houses, the demand for finished and semi-finished articles is expanding. There is a strong belief that the Solingen manufacturers are adopting a waiting attitude until the deliberations of the Allied Conference have finished, and then, if the Dawes Scheme is put into operation, will flood the British markets with cheap inferior goods. The call for automobile steel is increasing, especially for the Midlands, but now that the McKenna duties have been abolished an adverse effect will be felt in the near future. Of the heavy steel trade the railway department is the best employed, and makers of axles, tyres, wheels and other spares report good business and full time. More work, however, is required to replace expiring contracts. The Colonies continue to purchase large quantities of tramway track work and agricultural implements, while the call for mining requisites and electrical plant is on a slightly increased scale. In the lighter trades manufacturers report a slight improvement both for home consumption and for export to overseas markets.

South Yorkshire Coal Trade.—The closing down of pits for two days' holiday has resulted in a big decline in output. On the whole, business is very quiet, and collieries have big surpluses to dispose of before normal output can be restored. The call for best steam hards is very weak both on home and export account. Cobbles and nuts show improvement, but continue far below the average. Slacks are firm, especially the better grades, while inferior sorts are only moderate. House coal represents an improvement in regard to country purchases, but town demand has declined. The output of furnace and foundry coke is very small owing to the request being weak. Gas coke is firm. Quotations: Best branch handpicked, 32*s.* to 33*s.*; Barnsley best silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*; Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

SUBSIDISED TRANSPORT.—The War Office announces that until further notice vehicles may be enrolled under the War Department subsidy type light lorries scheme for the full period of three years. This will ensure the payment to owners of 120*l.* per vehicle, at the rate of 40*l.* per annum, subject to the mechanical efficiency and condition of the vehicle when inspected half-yearly. Where, however, it is anticipated that a vehicle fitted with alternative wheel equipment in lieu of giant pneumatic tyres is likely to be subjected to particularly arduous employment, the period of initial enrolment may be limited to one or two years at the discretion of the War Department. Where it is desired to include the body in the terms of the agreement, the ordinary commercial type body will be accepted provided the available platform area is sufficient to take the War Department load of 30 cwt. For this purpose a platform area of not less than 54 sq. ft. is normally required.

THE LATE MR. THOMAS LUMSDEN.—The founder of the Lumsden Machine Company, Limited, of Gateshead, and a prolific inventor of devices for use in grinding operations, Mr. Thomas Lumsden, died at his residence at Gateshead on July 17, at the age of 56 years. He received his early training under his father and uncle, and later worked as a millwright in Messrs. Armstrong's works at Newcastle, where he acquired very useful experience in erecting heavy plant. After returning to the machine shop he devoted much of his time to gauge making and cutting tools. On giving up his post as leading hand on cutting tools with Messrs. Armstrong, he commenced business for himself, specialising on lathes of 3½-in. centres for model makers. In 1906 the Lumsden Machine Company, Limited, was started by him, and he remained as the managing director until his death. This firm, as is well known, devoted special attention to grinding machines and makes use of his many patents. Of these the oscillating tool grinder is perhaps the most notable, and his name will always be associated with this valuable appliance. During the European War he originated the idea of a National Tool Factory for making shell tools by grinding processes, and when the project was started he was appointed its director under the Ministry of Munitions.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig iron is not over plentiful. Makers' stocks are stated to be well sold, and though at present output is rather in excess of current needs recent fairly good home sales prevent the accumulations at makers' yards growing to any considerable extent. Export business is still almost impossible. Values are still on the downward curve, though producers are very reluctant to follow the movement and are hinting that values have about touched bottom. No. 1 is put at 90*s.*, but is said to be obtainable at sixpence to a shilling less. No. 3 g.m.b. is quoted 84*s.* to 84*s.* 6*d.*; No. 4 foundry, 83*s.* to 83*s.* 6*d.*; and No. 4 forge, 82*s.* to 82*s.* 6*d.*

Hematite.—East Coast hematite is plentiful and slow of sale. In this branch also the business that is passing is almost entirely confined to sales for home purposes. Mixed Nos. are 93*s.* and No. 1 is 93*s.* 6*d.*

Foreign Ore.—The position as regards foreign ore shows little or no change. Consumers continue to hold off the market, and sellers still base quotations on best rubio at 23*s.* c.i.f. Tees. Contracts could no doubt, however, be arranged on lower terms.

Blastfurnace Coke.—Durham blastfurnace coke is in only moderate request. Good average qualities are quoted 26*s.* to 26*s.* 6*d.* delivered to local users.

Manufactured Iron and Steel.—Continental competition in semi-finished steel continues keen, but purchases of foreign material are not very heavy. Most descriptions of manufactured iron and steel are still slow of sale, and as orders on hand are being well got through, a good deal of apprehension is expressed as regards the near future. Sheets are in heavy request, and makers, being well sold to the end of the year, are very firm in their quotations. The export price for No. 24 gauge galvanised corrugated descriptions is fully 18*l.* 10*s.* In other branches overseas trade is difficult to put through and quotations vary considerably, but for home business the following are the recognised market figures: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 8*l.* 10*s.*; billets (medium), 9*l.*; billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; and fish plates, 13*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal as cargo from South Wales in July amounted to 2,301,800 tons, which was the largest quantity shipped in any month since November last, and was 390,000 tons in excess of the volume of trade in June. There were, however, 27 working days in the past month compared with only 23 in the previous month. The volume of the trade in July forms a welcome surprise, for day-to-day business in the open market was very limited, and it is evident that most of the coal shipped in July was exported on contract account. Compared with July of last year, shipments were greater to all markets except those of Continental Europe. Shipments to Italy were increased from 360,700 tons to 364,400 tons, to South America from 353,800 tons to 387,330 tons, to Spain from 145,870 tons to 176,360 tons, to Portugal from 74,990 tons to 89,090 tons, to Greece from 10,680 tons to 30,990 tons, Canada from 24,150 tons to 31,980 tons, and to unclassified countries from 85,310 tons to 131,910 tons. On the other hand, those to France were reduced from 1,092,880 tons to 817,900 tons, to British coaling depots from 214,730 tons to 186,320 tons, Belgium from 73,810 tons to 19,860 tons, Holland from 50,860 tons to 20,270 tons, and to Germany from 73,490 tons to 5,090 tons. Compared with the corresponding period of a year ago, exports from Cardiff at 1,416,480 tons showed a reduction of 21,670 tons, from Newport at 370,290 tons, a fall of 115,600 tons, from Swansea at 275,370 tons, a loss of 42,300 tons, from Port Talbot at 213,950 tons, a decrease of 48,130 tons, and from Llanelly at 25,700 tons were 31,750 tons lower. Meanwhile, though new business is still insufficient to absorb the outputs, the tone of the market generally is steadier, due chiefly to the loss of production caused by the holidays and also to the fact that stoppages on account of unremunerative business have been frequent and numerous. Workmen employed at the Cambrian collieries, which turn out about 13,000 tons a week, have been given a fortnight's notice to terminate contracts because of the uneconomic selling prices available. Best Admiralty large coal is steady at 28*s.* to 28*s.* 6*d.*, and supplies are becoming less plentiful, while seconds are round 27*s.* 6*d.*, with Monmouthshires from 24*s.* 6*d.* to 27*s.* and smalls from 12*s.* 6*d.* to 17*s.*, according to quality.

SOUTHPORT'S ARTERIAL NEW ROAD.—This new road, Waterloo Road extension, was recently opened by the Rt. Hon. Harry Gosling, M.P., Minister of Transport, accompanied by Sir Henry Maybury, Director-General, Roads Department, Ministry of Transport. The construction of the road was carried out to a large extent by unemployed labour so as to provide relief for the distress which would otherwise have existed in the town. The surface of the road is 1¾-in. lithocrete laid on 7-in. concrete, reinforced with B.R.C. Fabric Reference No. 9, made by the British Reinforced Concrete Engineering Co., Limited, Manchester.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little movement of any consequence in the steel trade of Scotland during the past week and business has been of a restricted nature. The lull in buying which has been all too prevalent for some months back, is still in evidence and, owing to the unsettled state of the world's markets, buyers cannot see their way clear to commit themselves in any way whatever. The current demand is so poor that it is old contracts which are mainly responsible for keeping up the limited amount of employment at the works, and only a portion of the plant is running. The improvement which was talked of as very likely in the autumn has yet to put in an appearance, and up to the present there are few signs of any change for the better. Shipbuilding demands are almost sure to improve to a limited extent, but inquiries for shipment lots do not amount to any volume. The black sheet trade continues active, and light gauge sheets and galvanised sorts are still being inquired for, but delivery can only be promised for the back end of the year, so well filled are most order books. Heavy gauge sheets are not in much request. Home prices are steady but export rates are easier inclined. The following are to-day's market quotations: Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, ⅛ in. to ¼ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—No change for the better can yet be reported in connection with the malleable iron trade of the West of Scotland, and much difficulty is being experienced in keeping plant moving. Buyers are very little in evidence, and the lots being placed are mostly for immediate requirements and seldom amount to an appreciable tonnage. Prices are being maintained, with "Crown" bars at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the position shows little change, but there is an under current of opinion that some improvement is very probable soon. Such would be most acceptable, but inquiry fails to find any ground for the idea. The home market is buying sparingly, and consumers abroad are not taking up much of the local make, partly because of the foreign competition which our pig iron is meeting. The output at the moment is very small and may even be further curtailed yet. Prices are easier and to-day's quotations are as under: Hematite, 4*l.* 16*s.* 3*d.* per ton, delivered at the steel works; foundry iron, No 1, 4*l.* 18*s.* 9*d.* per ton; and No. 3, 4*l.* 13*s.* 9*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, August 9, amounted to 1,062 tons. Of that total 944 tons went foreign and 118 tons coastwise. For the corresponding week of last year the figures were 377 tons overseas and but 15 tons coastwise, making a total shipment of 392 tons.

THE BUSK STUDENTSHIP IN AERONAUTICS.—We are informed that the Trustees of the Busk Studentship in Aeronautics, which was founded in memory of Edward Teshmaker Busk, who lost his life in 1914 in an accident to an experimental aeroplane, have appointed Mr. John Cowan Stevenson, of Glasgow University, to the vacant studentship.

THE LATE MR. JOHN H. DUNLAP.—We note with great regret the death of Mr. John H. Dunlap, the secretary of the American Society of Civil Engineers, in his 42nd year, and offer our sympathy to the Society. Mr. Dunlap was severely injured in a train accident near Buda, Illinois, on June 30, and, in spite of the attention and care he received in the Presbyterian Hospital in Chicago, he died on July 29. He was formerly Professor of Hydraulics and Sanitary Engineering in the State University of Iowa, Iowa City. The work of the secretaryship of the Society of American Civil Engineers has been undertaken by no less than three men—Mr. Herbert S. Crocker, Mr. Elbert M. Chandler, and Mr. Dunlap—since 1920, when Dr. Charles Warren Hunt vacated the office.

MOTOR SHIP "SWANLEY."—We understand that the motor ship Swanley, the first vessel to be fitted with double-acting Diesel engines of British construction, has just completed her maiden voyage from Cardiff to Colombo without a hitch. This vessel, of 9,300 tons deadweight, was built by Messrs. Barclay, Curle and Co., Limited, Whiteinch, Glasgow, for Messrs. Harris and Dixon, of London, and is engined with a single-screw three-cylinder two-cycle double-acting Diesel engine made by the North British Diesel Engine Works, Limited, also of Whiteinch, Glasgow. Following her trials on the Clyde at the beginning of last month, the Swanley proceeded to Cardiff and loaded a full cargo of coal for Colombo. She arrived at Colombo on the 5th inst., having made a non-stop passage with the exception of the Port Said call on the passage through the Canal. From Cardiff to Port Said her speed was just under 10 knots, with the engines running at an average of 83·5 r.p.m., while the oil consumption amounted to 6 tons a day for the main engines and about 2 tons for the donkey boiler for auxiliary purposes. On her passage through the Canal the manœuvring qualities of the engine gave complete satisfaction to the Canal pilots. Between Suez and Colombo the vessel averaged 10 knots on a fuel consumption of 6¼ tons for the main engines, the revolutions being 85 per minute. The engines used on the motor ship Swanley have been illustrated and fully described in ENGINEERING (vol. cxv, page 794).

AUTOMATIC SUB-STATION FOR THE HENDON-EDGWARE EXTENSION RAILWAY.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 227.)

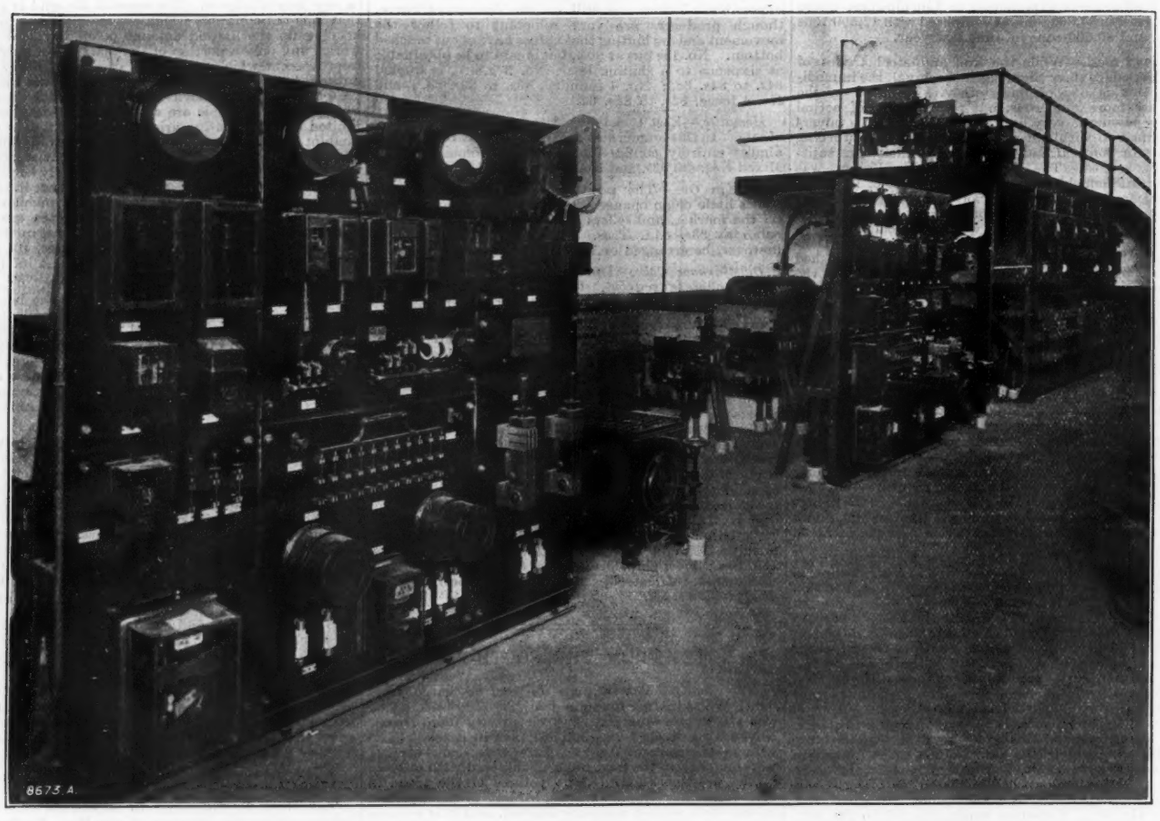


Fig. 3. General View of Direct-Current Switchgear.

Petters' Cold-Starting "S" Type Oil Engine.—This engine, manufactured by Messrs. Petters, Limited, of Yeovil, has been awarded the silver medal of the Staffordshire Agricultural Society. Exhibited at Walsall, the engine is of the medium-compression type and appears to have been favourably received on account of its quick starting properties, as it also secured the silver medal of the Royal Agricultural Society of England at Newcastle last year.

The Institution of Aeronautical Engineers.—Minutes of Proceedings, No. 9 of this Institution, reprints a paper on "The Loth Leader-Cable System for Steering Aeroplanes," by Mr. J. Gray, and a paper entitled, "Reminiscences of the Early Days of Aviation at Brooklands," by Mr. L. Howard-Flanders, together with the discussions on those papers. Copies of the Proceedings can be obtained from the Secretary of the Institution, 60, Chancery-lane, W.C. 2, price 1*s.* 6*d.*

The Professional Classes Aid Council.—The object of this organisation, which was founded in October, 1914, as "The Professional Classes War-Relief Council," and has been continued since 1920 under the above-mentioned title, is to assist men and women normally engaged in the engineering, scholastic, legal, medical, and all other professions and specialised callings, in times of adversity, arising from illness, unemployment or other causes. An important part of the Council's work consists in bridging over temporary financial difficulties while assisting applicants to obtain permanent employment, but much help is also given in the form of advice. Pecuniary aid is usually given in connection with the education and training of young persons or to cover expenses in connection with illness and convalescence. Representatives of most of the great professional bodies, of which we may mention the Institutions of Civil, Mechanical and Electrical Engineers, the Institution of Naval Architects, and the Institute of Metals, are included on the Council, and some particulars of its activities during the year ended April last are given in the annual report now available. Persons interested in the work of the organisation can obtain a copy of the report and balance sheet from the offices of the Council at 251, Brompton-road, S.W. 3.

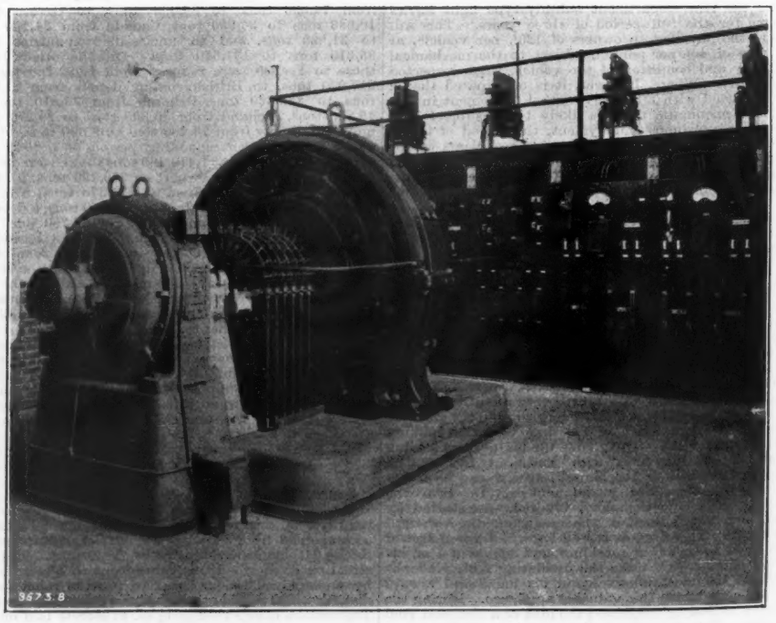


Fig. 4. Rotary Converter and Track Feeder Board.

THE QUEENSTON-CHIPPAWA WATER POWER DEVELOPMENT.

MR. F. A. GABY, CHIEF ENGINEER OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

(*For Description, see Page* 220.)

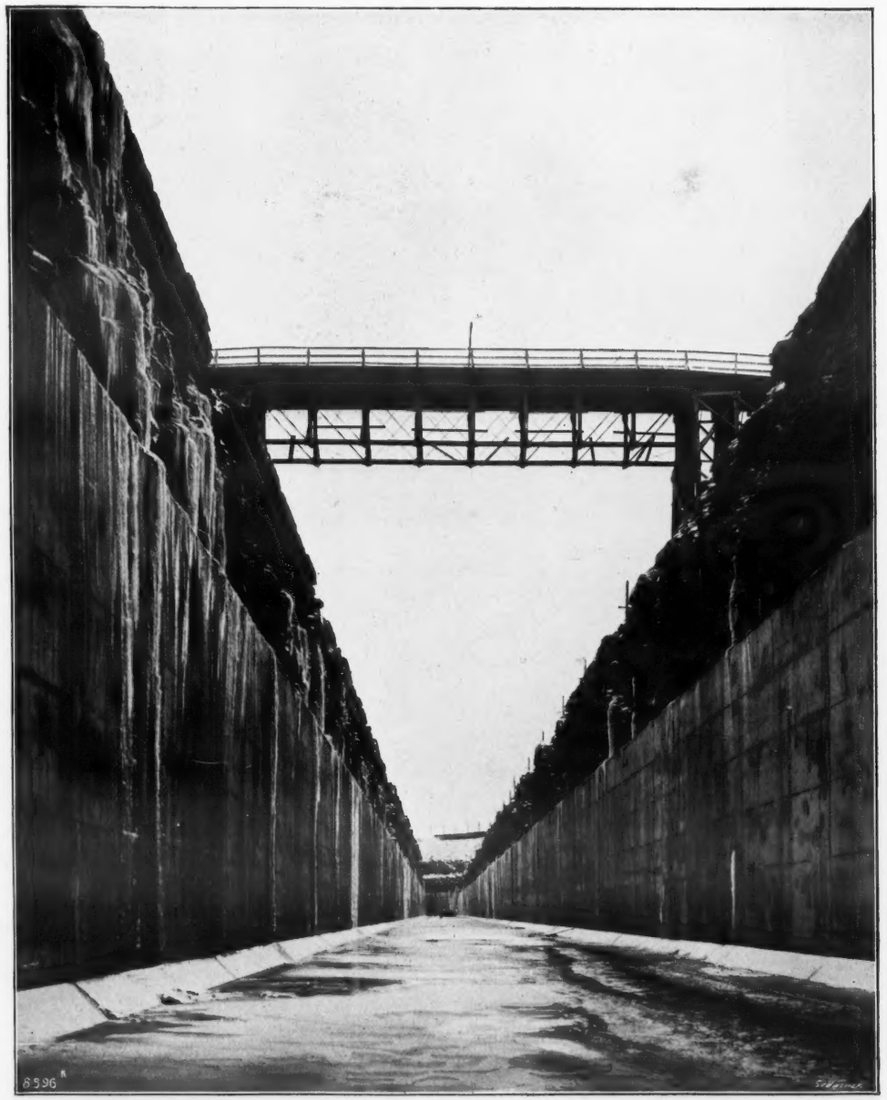


FIG. 12. CANAL IN ROCK SECTION.

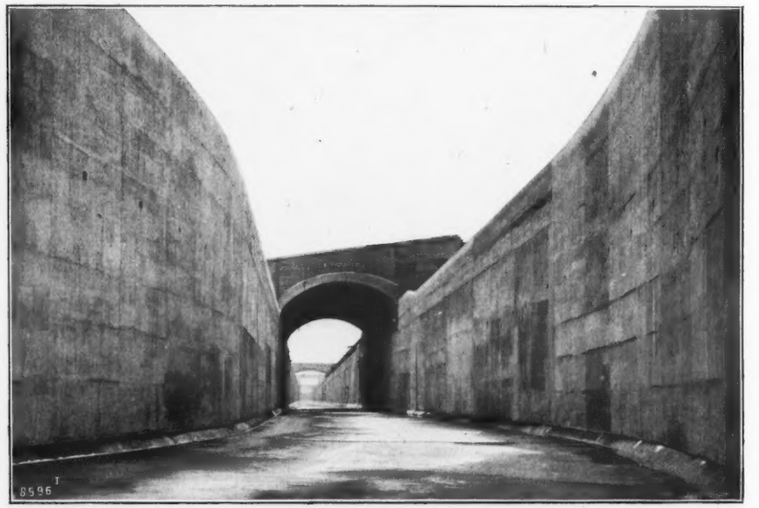


FIG. 13. CANAL SHOWING BRIDGES.

FIG. 14. WHIRLPOOL SECTION OF CANAL.

(*To face page* 220.)

THE QUEENSTON-CHIPPAWA WATER POWER DEVELOPMENT.

MR. F. A. GABY, CHIEF ENGINEER OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

(*For Description, see Page* 220.)

FIG. 15. POWER HOUSE AND TRANSFORMER STATION FROM U.S. BANK.

FIG. 16. VIEW OF FOREBAY AND POWER HOUSE.

FIG. 17. CONTROL GATE.

COLLIERY SWITCHGEAR AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. MAVOR AND COULSON, LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 224.)

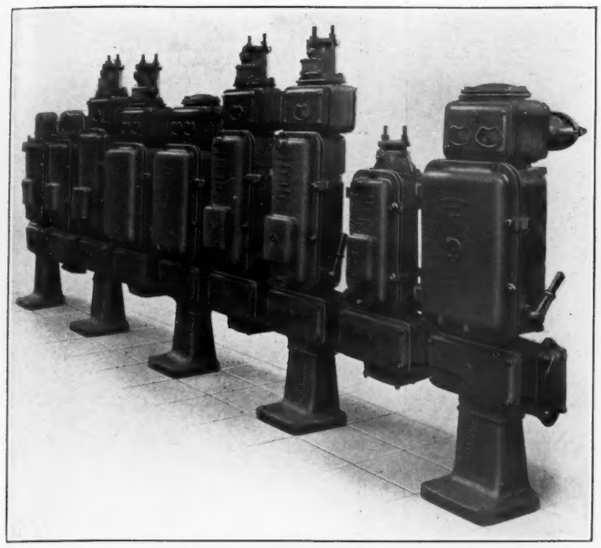


FIG. 98. NINE-PANEL, FLAME-PROOF, THREE-PHASE SWITCHBOARD.

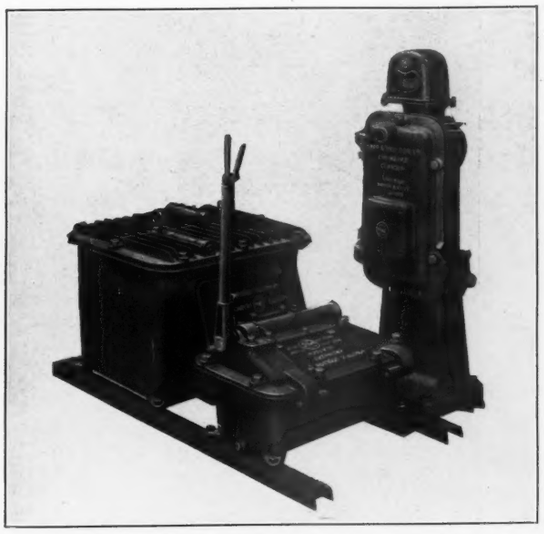


FIG. 99. 40-H.P. OIL-IMMERSED LEVER-OPERATED CONTROLLER.

FIG. 100. 120-H.P. OIL-IMMERSED WHEEL-OPERATED CONTROLLER.

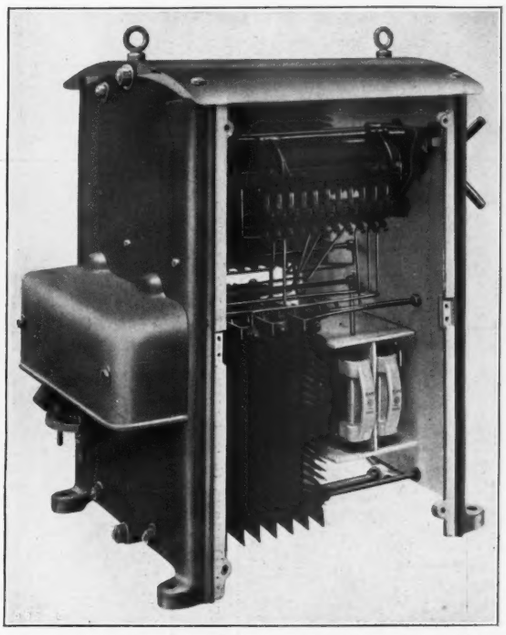


FIG. 101. PILLAR-TYPE CONTROL GEAR FOR NON-FIERY MINES.

FIG. 102 THREE-PHASE FLAME-PROOF ROTOR STARTER.

FIG. 103. SWITCH AND RESISTANCES FOR FLAME-PROOF ROTOR STARTER.

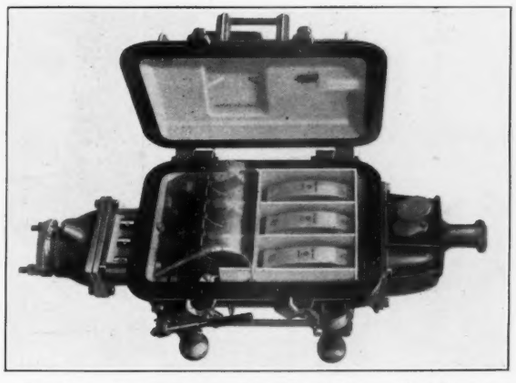


FIG. 104. THREE-PHASE GATE-END BOX. (THE METAL COVER IS INDICATED AS THOUGH TRANSPARENT.)

(*To face page* 224.)

FIG. 16. VIEW OF FOREBAY AND POWER HOUSE.

FIG. 17. CONTROL GATE.

COAL CUTTERS AND CONVEYORS AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 224.)

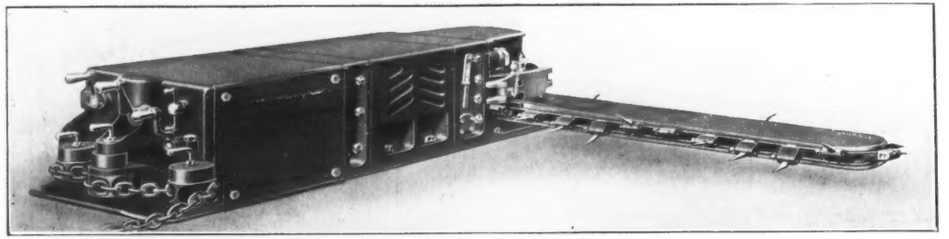


FIG. 105. COMPRESSED-AIR CHAIN-TYPE COAL CUTTER; DIAMOND COAL CUTTER COMPANY, LIMITED.

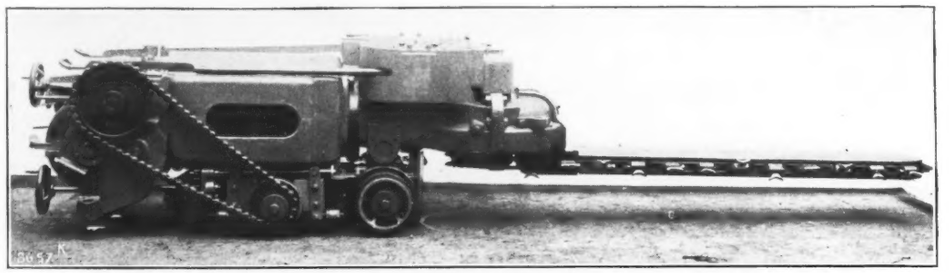


FIG. 106. ARCWALL ELECTRIC CHAIN-TYPE COAL CUTTER; MESSRS. MAVOR AND COULSON, LIMITED.

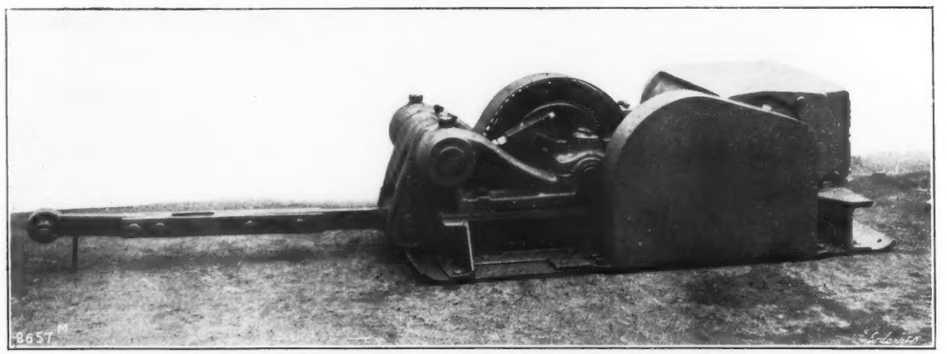


FIG. 108. DIRECT-COUPLED SHAKER CONVEYOR; MESSRS. MAVOR AND COULSON, LIMITED.

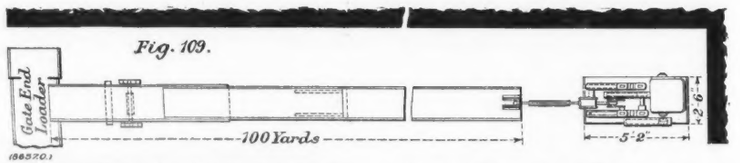


FIG. 109. DIAGRAMMATIC PLAN OF LONGWALL CONVEYOR WORKING.

FIG. 107. SISKOL SCALLOPING-TYPE COAL CUTTER; INTERNATIONAL CHANNELLING MACHINES, LIMITED.

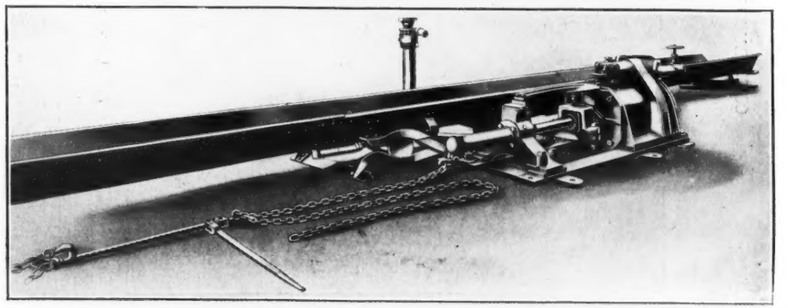


FIG. 110. COMPRESSED-AIR JIGGING CONVEYOR; DIAMOND COAL CUTTER COMPANY, LIMITED.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shilings for the first four lines, or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH: John Menzies and Co., Limited, Rose-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque For Advertisements, Office de Publications Commerciales 167 Rue Montmartre, Paris (2e).

GERMANY: Hermann H. Fromm, Potsdamerstr 105A, Berlin, W. 35. A Twietmeyer, Leipzig.

GLASGOW: William Love, 221, Argyle-street. John Menzies and Co., Limited, West Nile-street.

INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son, Limited.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and various branches and bookstalls throughout South Africa. Wm. Dawson and Sons (South Africa), Limited, 29, Long-street, Capetown.

TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart

UNITED STATES: For Subscription, New York: W. H. Wiley 440, Fourth Avenue. For Advertisements: J. S. Allan 30, Church-street, New York.

CONTENTS.

	PAGE
A Modified Temperature-Entropy Diagram for a Gaseous Working Substance (*Illus.*)	215
British Empire Exhibition: Pumps and Pumping Machinery.—III (*Illus.*)	216
Queenston-Chippawa Development of the Hydro-Electric Power Commission of Ontario (*Illus.*)	220
Balanced Manometer (*Illus.*)	223
The Colliery at the British Empire Exhibition (*Illus.*)	224
Automatic Sub-Station for the Hendon-Edgware Extension Railway (*Illus.*)	227
The German Iron and Steel Trades	228
Notes from South Yorkshire	229
Notes from Cleveland and the Northern Counties	229
Notes from the North	229
Notes from the South-West	229
The Progress of Civil Aviation	231
The Coal Survey	232
Italian Theories of Submarine Construction	232
Notes	233
The Salvage of the German Fleet at Scapa Flow (*Illus.*)	233
The Motor Tanker "British Aviator"	236
The Institute of British Patentees	236
Industrial Notes	237
Experiences of Industrial Welfare	237
Notes on New Books	238
Books Received	238
The Development of the St. Lawrence River for Power and Navigation (*Illus.*)	239
The Part which Bio-Aeration may yet Play in Purifying Sewage	241
Coal Measuring Apparatus (*Illus.*)	242
Electricity in Coal Mines	243
Catalogues	244
The Work of the Fatigue Panel of the Aeronautical Research Committee	245
ENGINEERING Patent Record (*Illus.*)	246

Four-Page Plates.—THE QUEENSTON-CHIPPAWA WATER POWER DEVELOPMENT. THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

ENGINEERING.

FRIDAY, AUGUST 15, 1924.

THE PROGRESS OF CIVIL AVIATION.

THOSE of us who are convinced of the ultimate success of the aeroplane as a means of transport, although still unsatisfied with the rate of progress made, have no reason to be discouraged by the results achieved of late. With one exception, each year completed since British civil aviation was inaugurated in May, 1919, has shown steady increases in the number of flights made, the mileage covered, the passengers carried and the goods transported, and there appears to be every likelihood that the rate of progress will be accelerated in the future now that the organisation has been simplified by the formation of Imperial Airways, Limited. This company, it will be remembered, now operates air transport services in Great Britain and Europe, carrying passengers, mails and goods on routes previously worked by four separate British concerns, viz., Handley Page Transport, Limited, the Instone Air Line, Limited, Daimler Hire, Limited, and the British Marine Air Navigation Company, Limited. For the first four years, commencing April 1 last, the new company has undertaken to complete an average minimum annual mileage of 1,000,000 in regular service flights, with an actual minimum mileage in each of these years of 800,000 and of 1,000,000 miles per annum afterwards, until the Government subsidy has been repaid. The subsidy agreed upon is of 1,000,000*l.*, payable to the company by decreasing annual sums over a period of 10 years.

The annual report of the Director of Civil Aviation, which has just been issued by the Air Ministry, covers the year ended March 31 last, during which period the British commercial air services were operated by the four companies above referred to. In the year under consideration, over 5,000 flights were made for transport purposes and over 1,000,000 miles were covered, as compared with 4,000 flights and 778,000 miles for the previous year. The corresponding figures for the number of passengers carried are 15,013 and 11,460 for the year covered by the report and for the previous year, respectively, while the cargo carried between April, 1923, and March, 1924, viz., 427·1 tons, was nearly double the figure for the year ended March, 1923, which was 216·4 tons. A useful development in the volume of traffic has thus taken place, and it is interesting and important to add that 88 per cent. of the total flights commenced were completed within the time allowed under the terms of the subsidies.

In analysing the causes of involuntary landings in respect of flights made by the subsidised British firms during the year recently completed, the report shows that, of a total of 4,033 flights commenced, only 351, or 9 per cent., were interrupted. The interruptions were mainly due to weather conditions, which were responsible for 213, or 61 per cent., of the forced landings, while engine or installation failures accounted for 91, or 26 per cent., of the stoppages; 47 landings, 13 per cent. of the total, were due to other causes. In practically all cases, these forced landings did not result in any injury to the passengers or crew, but they are nevertheless important, since some risk is always present in landing on unsuitable ground and in conditions of bad visibility. Actually, with the exception of one fatal accident which occurred on an established air route, no person carried in aircraft registered in the British Islands and flying for hire or reward was injured to any serious extent during the year covered by the report.

It will be remembered, that under regulations issued in 1922, all accidents arising out of, or in the course of, air navigation which occur in Great Britain, or which occur elsewhere to machines registered in Great Britain, may be investigated by the Inspector of Accidents. A total of 26 accidents, six of which resulted in loss of life, have accordingly been investigated during the year under review. Only five of these accidents occurred on the established air routes, the remainder having happened in the hire services or in short passenger flights, constructors' trials, competitions, training schools or in private flights. An analysis of the causes of these accidents seems to indicate that the human element is rather more often at fault than is the machine. Just half the accidents investigated were ascribed to errors of judgment on the part of the pilot or crew, this being given as the cause of the one accident, above referred to, which resulted in the loss of passengers' lives. In this particular case, the pilot stalled the machine at a low altitude when manœuvring to land in consequence of bad weather, and all the occupants, including a second pilot and three passengers, received fatal injuries. The weather was thus the primary cause of the accident although the pilot's error was the immediate cause. Actually, of course, the occasions on which the pilot is able by his skill and resource to prevent accidents which would otherwise result from mechanical failures or unfavourable conditions must be considerably more numerous than those on which he is in any way at fault. Such cases, however, can hardly be covered by statistics.

Of the remaining accidents, two, neither of which occurred on the established air routes, were due to defects in aircraft structure or controls, eight to defects in the engine or power installation, one to weather conditions, and two to other causes. Most of the engine failures originated in comparatively trifling defects, three of the number being connected with the petrol system. In one case, a piece of paper in the oil tank, by interfering with the lubrication, caused the engine to seize, and another accident, which occurred during a test flight of a racing machine, was due to the complete failure of the engine probably owing to a fracture of a part of the timing gear. Three other accidents investigated were due, respectively, to an ignition defect, to a fatigue failure of a connecting rod, and to the warping and consequent seizure of the valves. None of the engine accidents had fatal results, except the last mentioned, and, in this case, the pilot, after alighting successfully on the sea, was drowned in attempting to swim ashore.

Amongst other matters of interest in connection with the progress of civil aviation, the report deals with the various exhibitions, competitions, &c., held during the year, particular reference being

Fig. 110. Compressed-Air Jigging Conveyor; Diamond Coal Cutter Company, Limited.

Fig. 109. Diagrammatic Plan of Longwall Conveyor Working.

made to the competitive trials of light aeroplanes which took place at Lympne in October of last year. Some particulars of these trials will be found on page 502 of our 116th volume. As a result of the trials referred to, the report states, the British aircraft industry has gained the leading place in light aeroplane construction, and this position, we may remark, is likely to be strengthened by the trials of light two-seater aeroplanes to be carried out at Lympne next month. In connection with these trials the Air Ministry has offered prizes to the value of 3,000*l.* for machines primarily suitable for training purposes. The Air Council is evidently greatly impressed, and as we think rightly so, with the possibilities of the light aeroplane, and, with a view to encouraging the development of this type of aircraft, have just announced the fact that they are prepared, with the aid of local authorities, to assist in the formation of ten light-aeroplane clubs in different parts of the country. The Air Ministry proposes to make each club an initial grant for the provision of approved types of light aeroplanes and an annual grant, for two years, towards the expenses of maintenance, &c. Certain conditions must be complied with by the clubs, each of which, for instance, must employ one or more qualified air pilot instructors and ground engineers, but, in addition to the financial assistance already mentioned, a grant will be made in respect of each member qualifying, in club aircraft, for the issue of a private pilot's licence.

Whether or not the scheme can be put into operation in the near future depends largely upon the results of the forthcoming trials of light two-seater machines, but it should, we think, appeal to all interested in the development of British aviation as a possible method of materially augmenting existing facilities for the preliminary training of pilots. At first it is hoped to secure the formation of flying clubs in the leading commercial centres of the country, and, as far as the London area is concerned, the Royal Aero Club has already undertaken to answer inquiries and receive proposals. In the meantime, the scheme outlined above gives an added interest to the results of the new trials, although the interest would, perhaps, have been more usefully stimulated if the announcement of the policy with respect to flying clubs had been made somewhat earlier.

THE COAL SURVEY.

The Mines and Research Departments have announced that the Government has decided to speed up the chemical and physical survey of coal deposits on which the Fuel Research Board has been engaged for some time, and to take measures for offering further encouragement to likely processes of low-temperature carbonisation that have reached the stage of commercial production. At the present time the survey is being conducted in the Lancashire and Cheshire and the South Yorkshire districts, with the co-operation of local committees formed by the Board, and it is to be assumed that an early step in its extension will be to form similar committees in other coal-bearing districts. The conditions on which sufficiently promising processes can be examined with the help of public funds and of the staff of the Fuel Research Board are to be announced shortly.

Little difference of opinion will be felt as to the wisdom and essential economy of these steps. While coal surveys were merely geological, or at best were coupled with chemical information in the form of proximate and ultimate analyses, which seldom meant much more than that a good deal of time had been spent on their preparation, the more exact survey of so heterogeneous a substance as coal was not an attractive enterprise for hard times. The Fuel Research Board's practice of examining coals for their behaviour on carbonisation, facilitated by its development of the Gray-King assay process, has given the survey a more practical meaning. Its records now show not only the position and extent of deposits, but also approximately the respective amounts of useful products they yield on being carbonised at a temperature of about 600 deg. C. It may be that with further use the method will be developed so as to give information of similar exactness for carbonisation at higher temperatures; but, in any event, the knowledge of the yield of a coal at a temperature to which it must certainly be exposed in any carbonisation process gives the survey a practical value that must be well worth its cost.

The decision to give active encouragement to promising processes of low-temperature carbonisation may be not less important. It is just on thirty years since Parker made the first practical proposals in modern times for such treatment of coal. Even at that date he saw clearly and stated accurately enough the important results it could yield both in producing a smokeless fuel and in obtaining valuable bye-products, and investors have spent considerable sums of money in erecting plants for carrying out his proposals and those of later inventors. Yet up to now no generally marketable products have resulted. The processes turned out to be of that class in which serious difficulties are found when it becomes necessary to translate small-scale work into large, and many of them seem to have been abortive, not because they have been shown to be impracticable or worthless, but because those concerned have not been able or willing to make the necessary experiment on a large scale before embarking on commercial exploitation. As a result many of these processes have been frustrated by engineering difficulties, which the exploiters had not the means of overcoming; and, although from a chemical point of view, the process of low temperature carbonisation is now sufficiently understood, these mechanical difficulties will have to be overcome with a completeness corresponding to the vast scale on which the industry is contemplated before it can be adopted safely on that scale as a means of providing essential products and finally abolishing the waste and mischief of smoke.

The Government has acted wisely in now placing the matter in the hands of the Fuel Research Board and in providing, as its announcement seems to imply, the funds necessary to enable it to take effective action. In common with the other bodies instituted by the Department of Scientific and Industrial Research, and indeed with that body itself, the Fuel Research Board had adopted a settled policy of co-operating with those who are engaged in work similar to its own, and not undertaking on its own account work that it can get done as well by others. From the date of its institution it appears to have kept in close touch with the developments of private industry, and its reports have taken due account of their results as well as of those obtained at its own Fuel Research station. It has, moreover, never shirked the difficulties involved in translating experimental results, even on a large scale, into practical manufacture. It may be believed, therefore, with confidence that it will not certify a process as fit and ready for commercial working until it has obtained demonstrative proof that it is so. Such proof in the nature of things cannot be had without facilities for working on a scale of which at least the units are of commercial dimensions and with an accuracy that is seldom or never required in commercial works. The Board has such facilities, and will be able to apply them to processes that offer a sufficient prospect of success. The result may be awaited with the assurance that the best is being done to end the gross burning of raw coal, if it is technically and economically possible to do so.

So far as concerns the coke to be produced by low temperature carbonisation, it is to be observed that as yet no large scale trial seems to have been made of the extent to which it can be freed from ash. In any use to which the coke may be applied this seems to be a matter of considerable consequence. It is a matter of figures to determine whether the cost of separating incombustible matter, with the loss of combustible constituents of coal that it may involve, is more or less than the value of the heat spent in heating inert substances in the fuel and of removing them from the furnaces or wherever else the ash may be deposited. For domestic uses, however, the presence of a considerable percentage of ash is likely to have further consequences, which may impede the use of an otherwise suitable fuel. Coke, by what process it is made, is more voluminous than coal for a given weight of combustible, and a larger volume will have to be burnt to give the same amount of heat, and the percentage of ash is necessarily higher in a similar proportion. If this excess of ash is not removed from the coal before it is carbonised the presence of this excess of ash will in itself be disliked; but what is of more consequence is that grates which are of the right size for the rooms in which they are placed when used for burning coal may be too small when they are used with coke, and may have either to be replaced or to be replenished at inconveniently short intervals. The question does not seem to be one that would arise in the early stages of a carbonisation process, but it may be hoped that it will receive attention before it is sought to place low temperature coke on the general market.

ITALIAN THEORIES OF SUBMARINE CONSTRUCTION.

Admiral Thaon di Revel's programme of naval construction allowed for 16 submarines, of a class which was not specified; and these boats, if added to the four already being built, would give the country a submarine fleet of 63 units in 1928. For various reasons the building of these 16 additional boats has not yet been authorised; and, whilst the matter is still in suspense, two very interesting contributions to the theory of submarine design have been published by Italian naval officers. Signor G. Sechi, in his "reflections upon submarines," insists upon their intrinsic limitations. He admits that the larger type of submarine cruiser may do great damage to commerce, but argues that it is only by leaving her submarine characteristics behind that she does so. If a submarine is to operate successfully against commerce on the ocean highways, at a great distance from her base, she must rely upon gunfire for destroying her quarry; this means that submarines of this kind will more and more approximate to surface cruisers which have the power to submerge. There is an important corollary to this. No submarine cruiser will ever have a total combatant power anything like equal to that of a surface cruiser. The larger types therefore tend to become hybrids both in conception and design. They will be bad submarines owing to their size; they will be bad surface cruisers, because their gun power will necessarily be low, and their range-finding apparatus will be handicapped by its proximity to the water line. In all this Signor Sechi practically repeats the brilliant arguments of Captain Castex, the author of "Synthese de la guerre sousmarine"; but he applies his conclusions to the Italian building programme. Powers with relatively low financial resources ought to concentrate upon torpedo-carrying submarines of moderate displacement, and use them as a first line coastal defence. It is a pity that Signor Sechi did not push his inquiries a little further to examine a question which is of the first importance to naval powers of medium strength such as Italy. The question is, simply, the degree of protection which ocean-going submarines can give to convoys of merchantmen which are likely to be attacked by surface cruisers and battle cruisers. If a type of submarine can be devised, which will safely escort fleets of merchantmen to harbour in the face of attacks from powerful surface ships, then, some of the most elementary assumptions of naval strategy will need revision. It should also be said that many British officers believe to-day that submarines can give convoys of merchantmen the necessary protection, either by delaying the movements of the attacking force, or by so damaging it that the loss or dispersal of the merchant fleet is a good exchange in military values.

The second contribution to the subject comes from Captain de Feo, who deals with the question by suggesting a special design of submarine, and by discussing its merits and defects. An "O" type submarine—which is the name he gives to it—would displace 1,020 tons, and be armed with two 4-in. anti-aircraft guns, and eight 21-in. torpedo tubes, for which she would carry 450 projectiles and 12 torpedoes. She would be fitted as a mine-layer with a store or 18 mines; but if, for any reason, it were decided to arm her simply as a torpedo carrier—that is, if the mines were removed—the number of torpedoes could be raised to 18. Her

normal fuel capacity would be 71 tons, but this could be nearly doubled. Her radius of action moving at economical speed, which is 8 knots, and with a maximum load of oil, would be 9,000 miles. Her highest speed would be 19 knots, and she could maintain it for 2,400 miles with a full cargo of fuel.

The peculiarity of the design is that all the flooding chambers are placed right ahead and right astern, and that the vital organs—motors, living quarters, batteries, &c.—are grouped between the two. The result of this is that only this central part of the submarine need be built to resist pressure. Captain de Feo claims that by thus reducing the specially strengthened part of the hull he economises displacement which can be devoted to combatant power. The advantages, taken in order, are as follows: (*a*) that, given equality of tonnage and resistance to pressure, the "O" type submarine has a lighter hull than any other type; (*b*) that, by its design, the "O" type submarine is 50 per cent. less vulnerable than any other. On this point the designer's argument is that a submarine must protect herself principally from mines and depth charges, as superior gunfire can generally be avoided by diving.

Dealing with each of these dangers in turn, Captain de Feo argues that, when a submarine passes through minefields, she generally strikes them in her fore part; so that, by placing the flooding chambers right forward, the design interposes a non-resisting section—which can be damaged without losing the submarine itself—between the danger and the vital organs. Similarly, depth charges will only do irreparable damage if they strike the central, resisting, part of the hull, which means that the vulnerable target is reduced by half. (*c*) That it is not necessary to put ballast along the keel line of an "O" type submarine, as it maintains sufficient metacentric height without it. Captain de Feo's proof of this point is necessarily long and intricate: he claims, however, that his submarine would have a metacentric height of fifteen inches when submerged, although the engines and batteries are higher placed than in other types. (*d*) That the "O" type submarine would be able to increase her speed and fighting power at a greater ratio for every ton of displacement than any other class. The first part of the claim follows from the economy of weight which is at the basis of the design, the second needs explanation. If a submarine's metacentric height is to be maintained, the weight of additional armament, being always placed above the centre line, has to be compensated by placing additional weights below it. These additional weights are paid for by lower battery power, and less resistance to pressure. The British M type, for instance, has paid for its armament of 12-in. guns by only being able to resist pressure up to 100 ft. Captain de Feo claims that an "O" type submarine, with its great metacentric height, could mount a 12-in. gun without adding compensating weights along the keel line, which means that she could do so without loss of speed or capacity to submerge deeply. Captain de Feo might, with advantage, have been slightly more explicit on this point. He means presumably that an "O" type submarine can mount a 12-in. gun without loss of anything but metacentric height, that is, of stability: he would, however, have done well to support his contention by calculation. (*e*) That the centralising of all vital organs and manœuvring mechanism is an advance on all other types. The sub-divisions and compartments of all submarines of the "double hull" type make it difficult for the commanding officer to communicate his orders rapidly and effectively to all parts of his vessel. (*f*) During the war it was found that the slightest leak in the accumulator chambers created poisonous gases, as the water had immediate access to batteries. By being able to place the accumulators relatively high up, as he can do owing to the high stability of his vessel, Captain de Feo claims that he has secured a great factor of safety. (*g*) By keeping the flooding chambers at each extremity, the ship maintains a big transversal metacentric height whether she is on the surface or submerged. The designer's other claims more or less follow from those already enumerated, and need not be described.

The criticisms which could justly be levelled against the design are that the "O" type would lose protective strength by having only one hull; that the chambers at either extremity would not be easy to flood; and that the position of the accumulators is not satisfactory in that it leaves them insufficiently isolated.

Captain de Feo's design seems to be the outcome of a theoretical principle which developed during the war. In 1918 and 1919 it was generally stated that submarines, being slow, without vision and very vulnerable, could not possibly survive the means of destroying them which had been devised during the course of the war. There is a great deal in this contention; and it has to be admitted that, in spite of its mechanical development, the latest German U-boat had not really overcome the inherent limitations of the first Holland boats. Submarines will only make real advance if designers strive earnestly to get away from the "congenital defects" of the existing type. Captain de Feo doubtless regards his "O" boat as a first contribution.

NOTES.

The Whitworth Scholarships.

The regulations which will govern the examination for Whitworth scholarships in 1925 have now been issued, and can be obtained from H.M. Stationery Office, Imperial House, Kingsway, post free for 2½*d*. The scholarships are divided into two grades. Of the lower grade six will be awarded, of an annual value of 125*l*., tenable for three years. Candidates for these must be under 21 years of age on May 1, 1925. In addition they must have attended a regular technical school, those who are living in a remote village and have had to attain their knowledge of mechanical principles by private study being definitely barred by the requirement that laboratory note books certificated by a teacher must be submitted. This meticulous care for the vested interests of the teachers is also shown in the regulations for the senior scholarships. Of these, two will be awarded of an annual value of 250*l*. tenable for two years. Candidates for these must be under 26 years of age on May 1, 1925, and the standard of attainment required will correspond to that necessary for a University honours degree in Engineering. It is stated that in both grades the examiners will attach special importance to a clear understanding of fundamental principles. Judging from the syllabus a fairly extensive mathematical knowledge will be required from candidates for the senior scholarships. The Board of Education will not allow successful candidates in either grade to hold other scholarships or exhibitions without their written consent, and no appeal will be allowed from their decision should this consent be inexplicably withheld.

Carbonisation of Seaweed.

In various parts of the country seaweed used to be collected for kelp burning, and afforded an appreciable amount of employment in districts where it was and still is badly wanted. The system of burning was crude and primitive, involving the loss of a large part of the available products; but dry seaweed contains anything from a twelfth to a sixth of its weight of chloride of potash, besides about 6 to 8 lb. of iodine to the ton, and this would doubtless be worth having if it could be extracted at a suitable cost. The Fuel Research Board has just published some trials of the effect of substituting for the somewhat barbarous practice of burning the weed in order to recover its salts, or so much of them as are not lost in the operation, the more rational process of carbonising it in a closed retort, collecting the products of distillation, and dissolving out the salts from the residual charcoal ("Carbonisation of Seaweed." H.M. Stationery Office). The results seem to show that the gas evolved in the process would, with the combustion of the residual charcoal, provide heat enough to effect the carbonisation in addition to assisting the previous air-drying, and a fair yield of tar. These results are derived partly from laboratory assays on the useful Gray-King method and partly from larger scale carbonisations in the low-temperature retorts of the Fuel Research Station. Further trial would be necessary, as the report points out, to verify the economical soundness of the process. The question could, however, be settled without great cost, and having regard to the not over plentiful supplies of potash and iodine available in the country, the desirability of cheapening potash for agricultural purposes, and the advantage of reviving an old industry that seems to have been crowded out by the imperfection of its methods, the trial seems worth making.

THE SALVAGE OF THE GERMAN FLEET AT SCAPA FLOW.

In June, 1919, it will be remembered, the German residual crews on the naval vessels in Scapa Flow, opened the sea cocks and caused all the ships to fill with water and sink. If they ever imagined then that the vessels would eventually be raised, there can be no doubt that they never contemplated the possibility of one of their own floating docks being used for the purpose. The enterprise of a very resourceful organisation in salvage work and shipbreaking has, however, made this possible, and to-day what was once a floating dock, used for testing submarines by the German naval authorities, is in commission raising the various units of the ex-German fleet. We are enabled, through the courtesy of Messrs. Cox and Danks, Limited, of 168, Regent Street, London, the well-known shipbreakers who have the work in hand, and who demolished the dreadnoughts Orion and Erin at their yard at Queenborough, Sheppey, in compliance with the terms of the Washington Treaty, to show how the erstwhile floating dock was converted for use in its new service and to illustrate the first example of the work done with it.

The floating dock in question was referred to in an article entitled "Floating Dock for Testing Submarines" which appeared in our issue of February 25, 1921, when many of its constructional features were illustrated. Further illustrations of the dock were given in our issue of October 5, 1923, accompanying an article on "Shipbreaking at Queenborough." When Messrs. Cox and Danks, Limited, undertook the work of salving the German vessels at Scapa Flow, it was decided to convert the old submarine dock into two pontoons for use in the operations. In its general construction the dock was similar to other floating docks but had a cylinder, some 380 ft. long, erected along the middle length. This was provided with doors for the admission of submarines, and in it the submarines were tested under external pressure. For the new work it was decided to remove one of the side walls and to remove the long testing cylinder. This work is seen in progress in Fig. 1, page 234, which shows that a large part of the near side of the floating dock has been removed. The demolition continued until all the side had been cut down and the tube had been dismantled and the parts removed. In this state the structure is shown in Fig. 2. Shafting of 6-in. diameter and substantial pulleys for chains or wire ropes were erected along the new face of the pontoon and it was then towed to Scapa Flow.

In Fig. 3 the dock is shown as it appeared when being towed to its new sphere of service. Although it was not intended to use the dock in this state, it was kept whole in order that the expense of towing should be kept down to a minimum. Only when it was transferred to the place of its use was it cut into halves to obtain two pontoons of about 200 ft. length and 80 ft. breadth. Each of these had ten sets of winches, by the use of which the wire rope of a block and tackle may be taken up in order that the chains or main ropes placed under a vessel, which is to be raised, may be pulled up.

Some idea of the method of using the two pontoons, with one at each side of the sunken craft, may be obtained from an examination of Fig. 4. This illustrates what the equipment looked like at the time of the first endeavours to raise a torpedo boat destroyer. It will be noticed that for lifting purposes both chains and wire ropes were used to pass under the vessel, and that they received their motion from the winches and tackle on the two pontoons. This first attempt proved unsuccessful as there was a very bad weld in one of the chain links, which were made of 3½-in. metal. When the vessel was raised a few feet, this link gave way and its collapse was followed by that of links of the other chains. The effect of this upon the shafting, which was of 6-in. diameter, is shown in Figs. 5 and 6. After this experience Messrs. Cox and Danks, Limited, decided to replace all chains by wire ropes to obtain greater safety in working, and make success certain. These wire hawsers were widened out at the centre to obtain a flat belt-like surface at the places where they come into contact with the vessel.

The new arrangement is illustrated in Fig. 7, where

THE CONVERSION OF A FLOATING DOCK FOR SUBMARINE TESTING INTO PONTOONS FOR SALVAGE PURPOSES.

MESSRS. COX AND DANKS, LIMITED, LONDON.

FIG. 1. PART OF SUBMARINE CYLINDER AND SIDE WALL REMOVED.

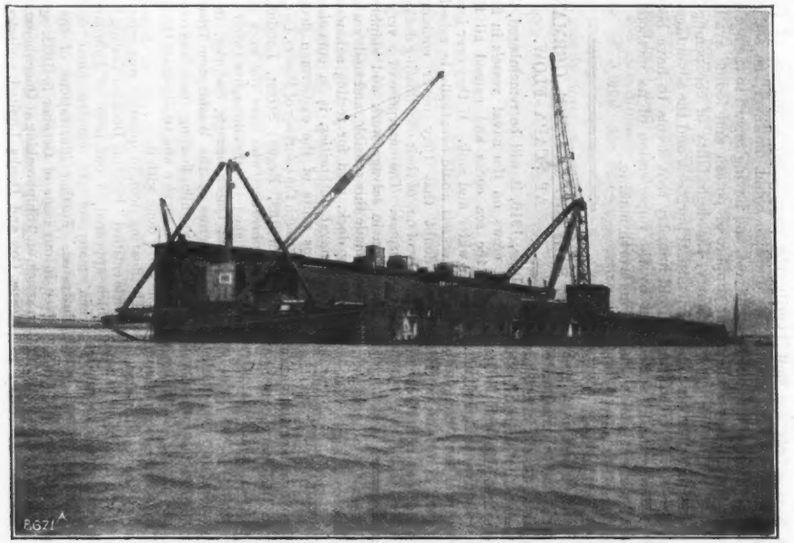


FIG. 3. THE CONVERTED DOCK IN TOW ON ITS WAY TO SCAPA FLOW.

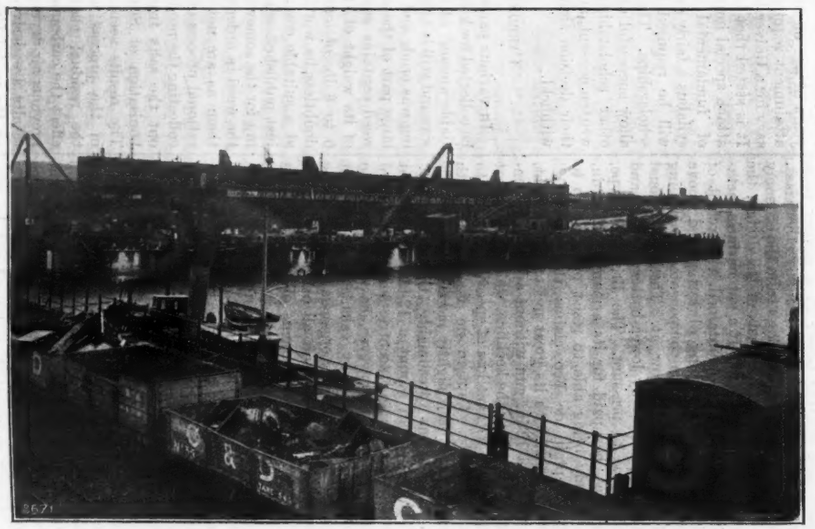


FIG. 2. WORK AT QUEENBOROUGH COMPLETED.

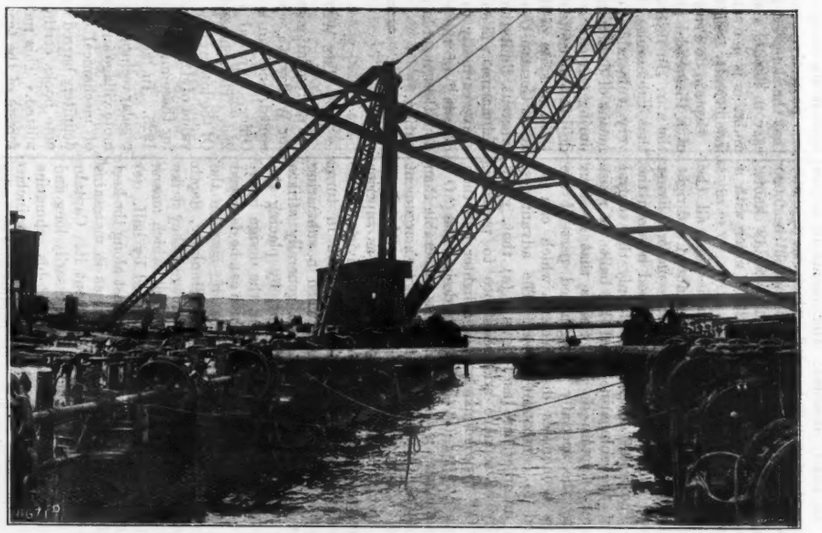


FIG. 4. THE TWO PONTOONS IN USE WITH CHAINS FOR LIFTING A VESSEL.

THE SALVAGE OF THE GERMAN FLEET AT SCAPA FLOW.

MESSRS. COX AND DANKS, LIMITED, LONDON.

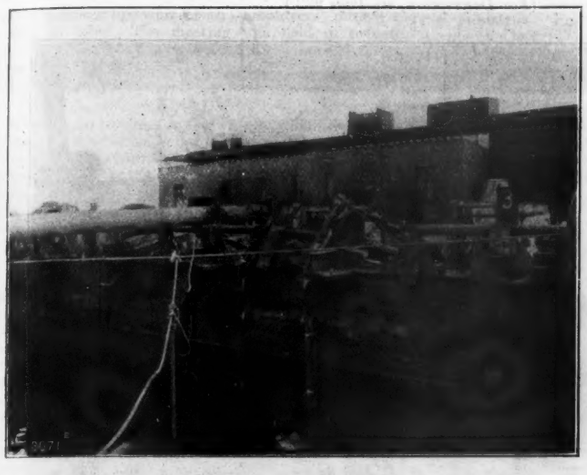


FIG. 5. EFFECT OF BREAKAGE OF THE FAULTY CHAIN LINK.

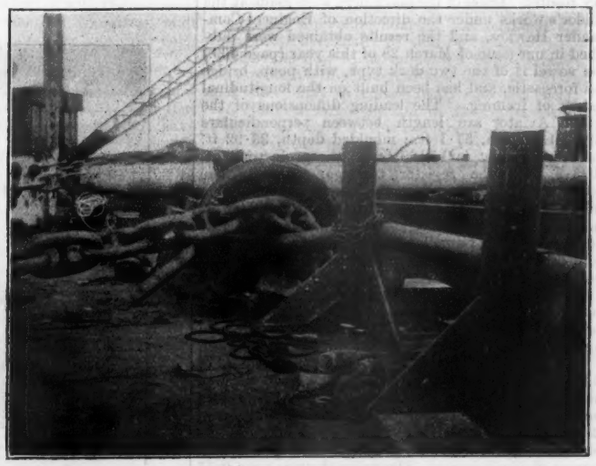


FIG. 6. PULLEY SHAFT OF 6-INCH DIAMETER AFTER THE ACCIDENT.

FIG. 7. TORPEDO BOAT DESTROYER V70 BEING LIFTED WITH WIRE ROPES.

the raising of torpedo destroyer V 70 is shown in progress. It will be noticed that the two pontoons are maintained in association with one another by the use of timbers lashed to each. The winches are of 10 tons capacity, and are treble geared and operated by hand. The rope from the winch is passed round pulley blocks with 5 or 6 sheaves, and, to the block near the pulley on the edge of the pontoon, the main or lifting rope is connected. Wire ropes are used throughout, that passing through the blocks being a 4-in. one, while the main one is of 9-in. size. The main pulleys are of 3 ft. 6 in. diameter and, having been made originally for chains, they have lips at the sides of the rims in addition to grooves made in them where the lower parts of the chain links were previously accommodated. In the actual operation, after the load was lifted a certain amount, it was necessary to take up some of the lifting rope in order that the blocks could be reset at the maximum distance apart for further working. It was found that this could be successfully and easily accomplished, one rope at a time, until the whole series had been satisfactorily adjusted, when the lifting could be resumed by working all the winches.

On August 1 the first successful lift was accomplished. The ten main ropes had been previously placed under the torpedo destroyer V 70 by divers, and at dead low tide, 4 a.m., the operations were begun by making all the ropes taut. The rise of the tide was thus used to assist in drawing the vessel out from the position it had taken up five years previously when it was scuttled and sunk. Hauling was started and was accompanied by the continuous rise of the tide. By 11 a.m., the pulleys for the main lifting ropes had been given a complete turn, so that the vessel had been raised through a distance of over 10 ft. relative to the pontoons. The torpedo boat destroyer was then about 2 ft. below the surface of the water. The effect of the suspended load acting at the edges of the pontoons is shown by the slight tilting observable in Fig. 7. While the destroyer was thus suspended the two tugs Ferrodanks and Lyness, belonging to the firm, towed the pontoons a distance of 1½ miles and got her into shallow water at Mill Bay on the island of Hoy. Photographs of the vessel were taken by *The Times*, and it is through an arrangement they made with Messrs. Cox and Danks, Limited, that we are enabled to reproduce Figs. 8 and 9, page 236. When the destroyer was deposited its deck was awash, but Fig 9 shows its appearance when the tide is down. From this location the vessel will be taken to the Admiralty Pier for breaking up. After five years' immersion the craft is naturally covered with barnacles, moss and seaweed. In this undignified state the vessels of the German Navy are being recovered merely for the sake of the metal they contain.

As a salvage operation, the speed with which the work was accomplished is worthy of emphasis. The use of the pontoons made the work comparatively light, and it cannot be denied that it forms a splendid example of how resources may be turned to the successful and easy accomplishment of what might otherwise have been a formidable task. The torpedo boat S.53 was also successfully raised yesterday morning (Thursday), and is now at Mill Bay. Further operations will follow, and we trust that these early successes are an index to the results that are to be attained in the complete endeavour.

THE INSTITUTION OF GAS ENGINEERS.—Mr. J. Ferguson Bell, M.Inst.C.E., Engineer and General Manager of the Derby Gas Company, has been elected President of the Institution of Gas Engineers for the year 1924–25. He has also been elected an Hon. Member of the Société Technique de l'Industrie du Gaz en France, for the same period. The Institution at its recent meeting elected to Hon. Membership the President of the French Society and also the President of the American Gas Association.

LOCOMOTIVES FOR PORTUGAL.—A confidential report on the market for locomotives in Portugal has been prepared by the Department of Overseas Trade from information received from H.M. Consul at Lisbon, and is issued to firms whose names are entered upon its special register. United Kingdom firms desirous of receiving a copy of this report, together with full particulars of the special register service and form of application for registration, should communicate with the Department, 35, Old Queen-street, London, S.W. 1.

THE INSTITUTION OF PUBLIC LIGHTING ENGINEERS AND SUPERINTENDENTS.—The first annual meeting of this Institution takes place in Glasgow on September 16 and 17. On September 16 the members and delegates will be received by the City Corporation of Glasgow and entertained to luncheon in the City Chambers. On the same day the President (Mr. Langlands) will give his presidential address. Papers will be read on both days. Further information can be obtained from Mr. W. J. Liberty, Lighting Inspector's Office, Guildhall, London E.C. 2.

"ANUARIO DE MINERIA."—The annual directory of mines, metallurgy, electricity and other works and establishments in Spain, vol. xxiv, for the current year is now available. It is edited by Mr. A. Contreras and Mr. R. Oriol, and is published by the "Revista Minera, Metalurgica y de Ingenieria," Madrid, at the price of 12 pesetas. It contains lists of all the Spanish mines classified according to metals and provinces, also of the mining, metallurgical, electrical and chemical undertakings, with their address, capital, administrative boards, &c. The information given contains the fees of the School of Mines' laboratory for examining and analysing ores, customs duties, and other business data.

FIG. 4. THE TWO PONTOONS IN USE WITH CHAINS FOR LIFTING A VESSEL.

FIG. 2. WORK AT QUEENBOROUGH COMPLETED.

THE MOTOR TANKER "BRITISH AVIATOR."

The builder's trials of the latest vessel to be added to the fleet of the British Tanker Company, Limited, have just been carried through with completely satisfactory results. Trials of the machinery were made at the builder's works under the direction of Engineer-Commander Hawkes, and the results obtained were published in our issue of March 28 of this year (page 409.) The vessel is of the two-deck type, with poop, bridge and forecastle, and has been built on the longitudinal system of framing. The leading dimensions of the British Aviator are length between perpendiculars 439·8 ft.; beam, 57·1 ft.; moulded depth, 33·92 ft. The displacement is 14,160 tons; the gross tonnage, 6,998·3, and the register tonnage, 4,135·8. The vessel was built and engined by Palmer's Shipbuilding and Iron Company, Limited, of Hebburn and Jarrow, and is fitted with a single-screw Palmer oil engine (built under the Camellaird-Fullagar patents); complete drawings of this engine appeared in Engineering on August 31, 1923.

On the sea trials the maximum indicated horse-power developed amounted to 3,720 and the shaft horse-power to 2,950 at 82·5 r.p.m., which corresponded to a fuel consumption per shaft horse-power of 0·408 lb. of Anglo-Persian Diesel oil, of a calorific value of 18,900 B.Th.U. The fuel oil was not passed through the separator. The speed attained under these conditions was 11·7 knots. At a slower engine speed of 72·8 r.p.m. the shaft horse-power was 1,920, and the consumption was 0·404 lb. per shaft horse-power with a speed of 10·58 knots. The exhaust gases were used in the by-pass to one of the boilers in the first trial and raised steam, which is used for steam heating, cooking, &c., to a pressure of 9 lb. per square inch. A great feature of the system is that the boilers are already under steam on arrival in port, and the requisite pressure for steaming out the tanks, working auxiliary compressors and other purposes, can be obtained by the use of the oil burners in a few minutes. On Monday and Tuesday, the 11th and 12th, further tests were carried out at sea by the Marine Oil Engine Trials Committee.

THE INSTITUTE OF PATENTEES.

The objects of the Institute of Patentees are to assist its members in developing and exploiting their inventions by giving technical and legal advice, and also to advise them as to whether or not inventions are likely to be of commercial value. In pursuance of its policy the Institute organises each year an exhibition of members' inventions, to which manufacturers and others interested in the acquisition of new inventions are invited. This year's exhibition, which was opened on Monday last at Aldwych House, Aldwych, W.C. 2, and will close to-morrow, includes drawings, models and examples of about 200 inventions, many of which, as might be expected, relate to domestic labour-saving appliances, furniture, toys and games, clothing, advertising devices, and miscellaneous articles which are quite outside our scope.

We noticed among the more technical exhibits, however, a simple and apparently effective device for bending the Simplex conduit used for electric wiring installations. For this purpose, curved-steel formers having a semi-circular groove on the convex surface and arranged so that they can be screwed on to the edge of a bench, are provided. The tube, which is placed in the groove and held in position at one end by a ring, is bent round the former by hand, its collapse being prevented by inserting a closely-coiled helical spring formed from stout steel wire.

In another device which may be usefully applied, the stroboscopic principle is employed for the observation of rapidly rotating or vibrating bodies, which can be made to appear to be moving quite slowly or to remain at rest. In this instrument, known as the Ashdown Rotoscope, the moving object is observed through slots formed across the body of a cylinder which rotates about a horizontal axis parallel with the observer's eyes. The cylinder is driven by clock-work mechanism, provided with change-speed gearing and a centrifugal governor, so that its speed of rotation can be varied over a wide range. The whole of the apparatus is mounted in a casing provided with a handle, somewhat similar in form to an ordinary stereoscope, so that it can be easily carried from place to place and used for determining the speeds of rotating bodies as well as for investigating their motion. We were informed that it could be employed over a speed range of from 150 r.p.m. to 40,000 r.p.m. We should, perhaps, explain that the effectiveness of the device depends upon the design of the slots, two of which are provided in the rotating cylinder—one for each eye. The slots contain a number of thin parallel plates of metal placed about $\frac{1}{8}$ in. apart, so that, when these plates lie in the line of sight, a comparatively large aperture is available for the passage of the light. The light, however, is completely cut off by a very small angular movement of the rotating cylinder, so that the period of vision is extremely short, and good definition is thus obtained.

Electrical apparatus, although usually given considerable attention by inventors, was not greatly in evidence at the exhibition, but we noticed a device for indicating, by means of a buzzer, when an electric lamp, such as is used for the tail light of a motor car, is extinguished. A complete list of the exhibits and particulars of any of them can be obtained from the secretary of the Institute, Mr. G. Drury Coleman, 44, Great Russell-street, W.C. 1.

International Conference on High-Tension Electric Distribution.—We are informed that the organisation of the third session of the above conference to be held in June, 1925, is now being proceeded with. The conference has for its object the study of problems connected with the production of electrical energy from hydraulic and steam sources, the distribution of power from the main to the sub-stations and the utilisation of high tension supply from the conductors.

THE SALVAGE OF THE GERMAN FLEET.

MESSRS. COX AND DANKS, LIMITED, LONDON.

(*For Description, see Page* 233.)

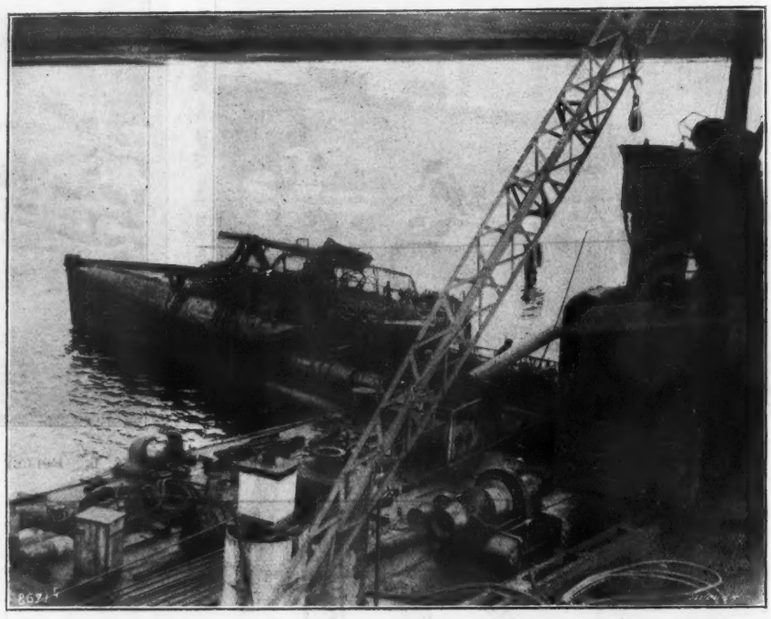


Fig. 8. The Salved Torpedo Boat Destroyer.

Fig. 9. Salved Vessel at Low Tide in Mill Bay.

Transformers for Tananaki Electric Power Board, New Zealand.—It is announced that the above board are calling for tenders for transformers to be received up to October 7. A copy of the specification and general conditions of tender are available for inspection at the Department of Overseas Trade (Room 52), 35, Old Queen-street, Westminster, S.W. 1.

Wairere Hydro-Electric Installation.—It is reported that Wairere Electric Power Board, New Zealand, is calling for tenders for the supply of a small hydro-electric plant. Tenders will be received up to October 7. A copy of the specification and general conditions of tender are available for inspection by firms desirous of offering British made supplies at the Department of Overseas Trade (Room 52), 35, Old Queen-street, Westminster S.W. 1.

Chile Wrought-Iron Tube Market.—A confidential report on the market for wrought-iron tubes and fittings in Chile has been prepared by the Department of Overseas Trade, and is issued to firms whose names are entered upon its special register. United Kingdom firms desirous of receiving a copy of this report together with full particulars of the special register service and form of application for registration, should communicate with the Department of Overseas Trade.

INDUSTRIAL NOTES.

THE joint committee formed of one member from each of the engineering trade unions interested in the national application for an advance in wages of 20*s.* per week, met in London on Tuesday, the 12th inst., as announced in our last issue, to consider the policy to be adopted in view of the employers' refusal to make an offer. The meeting was held in private. It is reported that a sub-committee was formed to consider the situation further and to report to the joint committee.

There is no progress to report in the building trades' dispute, notwithstanding repeated conferences at the Ministry of Labour. The Liverpool operatives still stand in the way of an agreement being reached, since they maintain their claim for separate treatment. The conferences held on Wednesday and yesterday would, however, seem to have brought the difficulty closer to a settlement.

Events seem to be moving towards a national strike in the electricity supply industry. The employers' side of the National Joint Industrial Council issued last Friday a statement saying that they wished the public clearly to understand that, after the fullest consideration had been given to the application by the trade unions for a general increase of 10*s.* per week, and the decision had been arrived at that no case had been made out for the increase, they offered to submit the matter to arbitration in the terms of the following resolution: "In view of the great importance of public utility undertakings, and bearing particularly in mind the strong recommendations of the recent Court of Enquiry in the tramways industry that arbitration should be resorted to in all matters of failure to agree, this Council, having failed to agree on the claims of a flat-rate increase of 10*s.* per week for all grades of employees, proposes that the matter be referred to arbitration." The employers added that this offer of theirs still held good; the Whitley Council had operated successfully for the past five years, and they regretted to think that its existence was now in peril by the refusal of the unions to accept arbitration. We understand that the strike notices were to be issued to-day, the strike to commence in a fortnight if the 10*s.* advance be not granted; it is hoped that it will not be of a national character.

It is announced that the railway companies have unanimously declined to entertain the applications made on behalf of the railway shopmen by the craft unions for advances in wages varying from 10*s.* to 12*s.* per week. The companies state that the standard time rates paid to railway shopmen conform very closely to those generally paid in the non-railway engineering industry, and since July, 1922, railway shopmen have been receiving an extra war wage of 6*s.* 6*d.* higher than that paid in non-railway engineering shops. So long as this anomaly continues the companies cannot find any ground for entertaining any general application for increased wages. The companies are willing to submit the claim of the craft unions to the Industrial Court, provided their own claim for the removal of the 6*s.* 6*d.* war bonus be also referred to the same Court. This question of the railway shopmen's wages is to be considered at a conference of all the craft unions to be held in London on the 22nd inst. It is understood that representatives of the National Union of Railwaymen are to be invited to attend.

It is announced that Messrs. Spear and Jackson, Limited, Ætna Works, Sheffield, whose interesting display at the British Empire Exhibition formed the subject of an article in our issue for May 23, have purchased the establishment of the Ætna Saw Company, Vancouver. These works are to be extended and operated under the name of Spear and Jackson (B.C.), Limited, and will supply the Canadian market with all the specialities of the firm.

The Board of Education has issued a Report by H.M. Inspector on Education in relation to Foundry Work, which gives a brief historical outline of the trade, a table on the distribution of foundries in Great Britain and Ireland, an indication of the subdivisions in the trade, followed by considerations on foundry work and a statement of the measures recommended for furthering the trade. The report states that in spite of the slightly higher pay accorded to foundry workers there is considerably less competition to enter foundries than other branches of the engineering and allied industries. This is no doubt due in part, the report adds, to the nature of the work and to the uncongenial conditions in which it is frequently carried out, but it is also due to the limited possibilities of advancement in the occupation, and to the lack of systematic schemes of instruction leading to the higher posts. The report gives suggestions for improving recruiting, and reviews various schemes for educating and training young moulders. It should be widely distributed throughout the schools of the country. We should like, however, to remark here that the possibilities of advancement in the foundry trade do not appear to us to be less than those in many other trades connected with the engineering industries. Further, numerous foundries built during the last twenty years or more can bear comparison with the other departments in a works.

We are glad to note from the report for July now issued by the United Patternmakers' Association that their 5 per cent. unemployment figures of June have been reduced to 4 per cent. in July, the total figures being 480 as against 598, and, like the secretary of the association, we hope the improvement will continue for many months to come.

Mr. Alfred Short, M.P., Mr. W. A. Appleton and Mr. Birchenough, representing the General Federation of Trade Unions, called last week on Mr. T. Shaw, the Minister of Labour, to place before him a resolution of the Federation asking that the Industrial Courts Act be amended in such a way that, on the request of any one party to a dispute, the Minister of Labour shall order an inquiry. As the Act now stands the matter is one for his discretion. It is considered probable that the Government will take the application into consideration.

The International Miners' Congress at its recent sittings in Prague has unanimously decided in favour of a resolution, put forward by the British and French delegates, and providing that in the event of a war being threatened the Miners' International Committee shall be immediately summoned and practical steps be taken to prevent war from being declared by the governments concerned.

Major-General Sir Frederick Sykes, the member for Hallam, Sheffield, has asked the Parliamentary Secretary to the Overseas Trade Department whether his attention had been called to proposals made in France to increase the French tariff duties on imported steel products and other goods by means of new classifications and by the adoption of a gold basis for the payment of the duties; whether he was aware that these proposals, if put into operation, would have a damaging effect on the British steel trade and employment in that trade; if he would state what representations had been, or would be, made to the French Government in the matter and what steps the Government were prepared to take, in the event of the proposals being adopted to secure markets for the steel products affected. Mr. Lunn replied that no official information was at present available as to the proposed rates of duty, and it was therefore not yet possible to form an opinion as to the effect of the new tariff on British trade, but the matter was being carefully watched and would continue to be. Representations had already been made to the French Government regarding certain changes in the tariff classification of steel which were reported to be under consideration by that Government.

A wages dispute has arisen among the men, numbering about 6,000, employed by Messrs. Steel, Peech and Tozer, Limited, Rotherham, the Park Gate Iron and Steel Company, Limited, Rotherham, and Messrs. Samuel Fox and Co., Limited, Stocksbridge. The men belong to the following unions: the Amalgamated Engineers; Electrical Trades; Blacksmiths, Boilermakers and Enginemen; National Union of General Workers; Workers' Union. It is reported that the skilled men on plant maintenance decline to work on a sliding scale instead of at district rates, as proposed by the employers, whilst the semi-skilled men are dissatisfied at the refusal by the employers to concede district rates of wages instead of the sliding scale now in use for this class of men. We understand that the steel smelters are not directly involved, but they may have to cease work should a strike of the maintenance men be declared.

The Federation of British Industries in its Bulletin for the 12th inst., quoting from its correspondent at Valparaiso, gives the result of a recent tender for locomotives for the Chilian State Railway. The Belgian and German offers were respectively 4,700*l.* and 4,750*l.* for each unit, whilst American manufacturers quoted 7,500*l.* and British 9,620*l.*

On page 176 *ante* we stated that the Hull Corporation Tramways Committee had ordered 1,500 tons of rails from Messrs. Bolckow, Vaughan and Co., Limited, notwithstanding lower offers for Belgian and German rails. News now comes to hand to the effect that the Hull City Council has reversed the decision of the Tramways Committee, and has placed the order with the Equipment and Engineering Company, London, whose tender, it is said, was 3,500*l.* cheaper. The rails are to be manufactured in Germany. It is further stated that the labour members of the City Council took the initiative in opposing the Tramway Committee's recommendation, and claimed that the rails would eventually be paid by exports.

The rails now to be purchased from Germany may very probably not be equal in quality to the British, and they may in consequence last less long, thus cancelling a large portion of the apparent saving. The loss in wages to this country is another consideration of great importance. Orders should never be allowed to go abroad, especially at the present period when the whole country is suffering from unemployment and the dole system, without weighing beforehand all the circumstances of the case. The fact that the labour members of the Hull City Council overruled the former decision in this instance would be passing strange were it not known that too many labour leaders appear to be friends of every other country rather than of their own.

EXPERIENCES OF INDUSTRIAL WELFARE SCHEMES.

UNDER what are now termed Industrial Welfare Schemes many interesting experiments have been made, which have given very valuable results. These included the provision of good working conditions in factories, the establishment of canteens where satisfactory meals can be obtained by the workpeople, the installation of first-aid facilities, the development of schemes for the education of the younger employees, and for the encouragement of initiative, the inculcation of thrift among the workers, the financial help in the erection of clubs and the laying out of recreation grounds. All of these activities have proved to be of great service in the creation of confidence between employers and their workers, and a practical aid in management. The Industrial Welfare Society has, during the six years of its existence, done much valuable service in propaganda work relating to these schemes—and its success has been due in large measure to the influence of its President, H.R.H. the Duke of York, and the Chairman of Council, Lord Invernairn.

While it might be accepted as axiomatic that any improvement in the condition of workpeople would be productive of contentment and result in smoother working between the various people in an industrial organisation, there are employers who like to base their decisions not on mere theory but on the actual experiences obtained in practical applications. The Society has, therefore, prepared a pamphlet entitled "Industrial Welfare: Opinions of Manufacturing Firms," in which is stated the considered judgment, based upon actual working, by many different organisations. If this testimony is indicative of the general experience, there can be no doubt of the value of welfare work as an important factor in good management. There are many engineering firms who have adopted the system, and what it means to them may be judged by their statements. Messrs. W. H. Allen, Sons and Co., Limited, are confident that the extension of the welfare movement throughout the country will go far towards solving the many problems of the times, and they strongly urge firms who have not instituted a scheme already, to do so without delay. It was found by Messrs. Beyer, Peacock and Co. Limited, that a welfare scheme was instrumental in creating a better type of apprentice, who took a keener and more intelligent interest in his work and had greater pride in the firm. The co-operation on the basis of mutual trust between workers and employers through welfare work had, said the representative of the British Thomson-Houston Company, Limited, removed the suspicion of ulterior motives, which had hitherto proved an obstacle to successful work. These quotations are few, but the pamphlet contains many from body-builders, electrical machinery manufacturers, marine engineering, and shipbuilding companies, steel workers, and in fact representatives of every phase of engineering work. This pamphlet, issued from the offices of the Industrial Welfare Society at 51, Palace-street, Westminster, London, S.W. 1, deserves wide circulation, and its careful study will well repay the reader.

SOUTH AFRICAN STEAM TURBO-CENTRIFUGAL PUMP.—It is announced that the Rand Water Board are calling for tenders to be presented before noon on Friday, October 3, 1924, for the supply, delivery and erection of one steam turbo-centrifugal pump, with condenser, piping and all accessories. United Kingdom firms in a position to supply British material can obtain further particulars on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, quoting reference A.X. 1230.

NOTES ON NEW BOOKS.

The railway literature of this country has, as we have often pointed out, been lacking in certain directions along which American authors have worked very successfully. A number of works on the locomotive, on railway signalling and certain phases of operation, rate making, &c., have emanated from our publishing houses, but for works on the engineering side of railway economics we have to go to America. Authors in that country were given a good lead by Wellington, and much of what has been subsequently written has been an elaboration of particular phases of the subject as treated by that pioneer. Many of the later works have a distinct value of their own—some elaborate in one direction and some in others, the object of all being, to adopt the words of a volume before us at the moment, to raise railroad location from a trade to a profession. The fact that our literature is wanting in this manner is probably due to the fact that railway extension practically ceased here before the economics came to be studied very carefully. More attention was paid to operation than to location, while, in America, extensions continue still, under favourable conditions, on a large scale. The study of economics from the location point of view is therefore of moment to engineers in that country, and it has long been recognised that the younger officials should grow up with an appreciation of fundamentals. It is to this end that books like W. G. Raymond's "*Railroad Engineering*" (Messrs. Chapman and Hall, Limited, London, price 22*s.* 6*d.* net) were introduced. This book, now in its fourth edition and reaching its eleventh thousand, is too well known even here to need commendation. Making allowance for differences between English and American practice, the work is useful to students in both countries. It has behind it the best authority, the author having had the assistance of such eminent railroad officials as G. W. Kittredge, W. J. Wilgus, and others. It will assist those fortunate enough to be involved in new work, as well as those whose object in life is the most profitable operation of existing systems.

Judging from recent publications on the subject of automatic telephony, the public would appear to be taking considerable interest in the details of the very complex mechanism involved. The difficulty of following such mechanism from diagrams is considerable, and it is doubtful if anyone, having no opportunity for studying a full working model will be able fully to understand all the details and the way they operate. There are none the less probably many who will be interested in Mr. Ellson's small work on "*Automatic Telephones*" (Sir Isaac Pitman and Sons, Limited, London, 1924, price 5*s.* net), in which he claims to have furnished an introductory treatise, dealing with the fundamental principles, methods, and advantages of automatic telephony. The explanation of fundamental principles is reduced to a minimum, and the contents may be better defined as a description of the operation and mechanisms in the best-recognised systems. The author, who is thoroughly at home with the different methods devised by the Automatic Telephone Manufacturing Company, the Western Electric Company, the Siemens Company, and others, describes them accurately, but those who approach the subject without previous preparation must be prepared to read the matter very carefully, and it is only the expert who will fully perceive and appreciate the relative advantages and disadvantages of the various designs. The advantages of automatic telephony are not only a great saving in time to the public, but by placing the work of calling subscribers on the user, instead of on paid officials, it is hoped to make a considerable saving on the annual charge, to be able to dispense with the services of many operators, and by occupying smaller premises to economise in rent.

The safety and comfort of passengers is of vital importance to the railway engineer, and, during the last few decades, much thought and time have been devoted to the improvement of conditions of travel. That the stability of rolling-stock moving at express speeds is, to a large extent, dependent on the condition and method of laying of the permanent way, is obvious, but M. Georges Marié, in his book, "*Traité de Stabilité du Matériel des Chemins de Fer, Influence des Divers Eléments de la Voie*," states that locomotive, rolling-stock and track should be considered together, instead of being treated as separate entities. This is a fact which, he says, has not always been borne in mind. The author, who has been many years with the Paris, Lyons & Mediterranean Railway Company, has written a number of papers bearing on the present subject, and these form the framework of this treatise now published. The various types of vibrations and oscillations set up within a moving train arising from irregularities in the track or bends in the road, as well as those due to such internal forces as inertia and gyroscopic influences, are treated as mathematical problems, and formulæ are worked out for each particular case. The author, quite logically, divides his subject into eight sections, the first six of which are devoted to the calculation of specific problems. In sections seven and eight, he descends from theory to practice, shows how to apply the formulæ obtained, and devotes a good deal of space to the interpretation of results generally. Altogether, the book will prove highly useful to all those interested in railway engineering. Many of the problems are viewed from a new angle, and the author claims that, with the exception of a stated few, all the formulæ given are his own. Like only too many French books, it has not an alphabetical index. The publishers are Librairie Ch. Béranger, 15, Rue des Saints-Pères, Paris. The price is 58 francs, or post free to England, 65 francs 50 centimes.

Mr. H. Goitein, of Gray's Inn, who was recently a distinguished student and is now a barrister-at-law, has written a concise little book, "*The Law as to c.i.f. Contracts*" (Effingham Wilson, London, 4*s.* net), on the special law governing those commercial transactions which are known as "c.i.f. contracts." The book deals with the nature of c.i.f. contracts, the requisites of their performance, the documents to be tendered, the cases where performance is excused, the passing of the property in the goods, and the rights and duties of buyer and seller. The author states the law in fifty-eight short paragraphs, which are followed in almost every case by short synopses of—or extracts from—the cases and judgments on which his statements are based. The book should be extremely useful to lawyers in commercial and shipping practice, both as containing a clear statement of the law and as a guide to the leading cases; but we think it would have been even more useful if the author had not set himself so severely to achieve brevity rather than a full and self-explanatory exposition of the subject. He seems to have cramped himself unnecessarily by his desire to observe what he considers "the necessary limitations of a text writer," and the book would have gained if it had been written more confidently and less cautiously. Although shipping law and shipping terms soon become familiar to lawyers who are engaged daily in shipping practice, there are many lawyers in general commercial practice who have only occasionally to deal with shipping matters, such as c.i.f. contracts, and a little explanation often goes a long way to help them over their difficulties. For instance, at the foot of page 41 there is a reference to "usual f.p.a. insurance," but the reader, if he does not know, is left to imagine what "usual f.p.a. insurance" means. On the same page, after a quotation of the contention of the buyers in a certain case, the author says: "The learned judge then goes on to show why this contention was untenable"—but why not give the Judge's reasons? And in other instances the synopsis of the case is so brief that one has almost to grope for the reasons for the decision. Of course an author is entitled to choose his own manner and to set and observe such limits as he thinks fit (if, indeed, these are not set for him by his publisher), and our criticisms are made merely by way of encouragement to the author of an excellent book. It is happily free from the over-punctuation which spoils so many law books; and perhaps in his next book Mr. Goitein will avoid such solecisms as "must necessarily" and "the question as to whether."

We have noticed several books by Dr. Friedrich Münzinger on boilers and steam storage. His latest contribution to this subject, "*Höchstdruckdampf*" (Berlin: Julius Springer; price 1·85 gold mark) was only completed a few days after the death of Wilhelm Schmidt, who successfully took up the application of superheated steam when the problem was practically abandoned by others, and is appropriately dedicated to him. In this new volume Dr. Münzinger discusses particularly the economical and technical aspects of the generation and utilisation of steam at very high pressures. By that term he understands pressures from 30 atmospheres upward; his deductions have necessarily to start from ordinary pressure ranges. He makes clear at the outset that no reliance can be placed, for high-pressure conditions, on the usually accepted strength-data and approved boiler constructions. In order to ensure efficient heat transference in the economiser, he would avoid long flues, dead corners and high flue-gas speeds, in the boiler the stresses should, as far as possible, be uniformly distributed over large surfaces. He does not anticipate particular trouble from the water circulation, and advises the use of not more than two nests of tubes of relatively small diameter keeping the number and dimensions of the steam drums small, and utilizing Ruth's storage boilers on the low-pressure side. The 120 diagrams of the volume of 140 pages illustrate both theoretical and constructive features. Dr. Münzinger advocates high pressures, combined with intermediate heating, especially in plants for both heating and power. With regard to the theory of the Emmet binary-fluid turbine he refers to our columns.

It is very difficult to say what a "*Chemical Encyclopædia: A Digest of Chemistry and Chemical Industry*" should contain, and what may be considered dispensable. Completeness would be an impossibility, even if there were no restriction on the number of volumes and their size. We will not discuss the question, whether or not a chemical encyclopædia should at present be condensed into one volume. But we think that Mr. C. T. Kingzett, F.I.C., gives a great deal of good and useful information in the 606 pages of his one volume of this title (Bailliere, Tindall and Cox, 8, Henrietta-street, W.C.2; price 30*s.* net). We have found most of the many items we have looked up, including dyad, celtium, hafnium, atomic number, ester value and fusain. Hardness and softness are missing, but we find permutit and, under it, doucil (misspelt doncil, one of the very few misprints we have noticed). Activation is only explained in a good article on charcoal and its activation; similarly the word floridin is missing, but fuller's earths from Florida are duly mentioned. Trade names are included, sometimes as in the case of "novit"—a proprietary amorphous carbon—with a rather surprisingly large space allowance. Lithium hydride, interesting because it liberates its hydrogen at the anode, is not described, nor is it stated that the alkali hydrides look like salts and not like metals. But that brings us back to the fact that the author must restrict himself often against his will. The volume represents the third edition of what was previously published as "The Popular Chemical Dictionary." We learn this from the preface, which is written in a style that would be more appropriate to the former than to the present title.

BOOKS RECEIVED.

United States Bureau of Mines. Technical Paper No. 350. *Accidents at Metallurgical Works in the United States during the Calendar Year* 1922. By W. W. Adams. [Price 5 cents.] No. 354. *Metal Mine Accidents in the United States during the Calendar Year* 1922. By W. W. Adams. [Price 10 cents.] Washington: Government Printing Office.

Electrode Reaction and Equilibria. A General Discussion London: The Faraday Society. [Price 10*s.* 6*d.* net.]

First (Experimental) Report to the Atmospheric Corrosion Research Committee (of the British Non-Ferrous Metals Research Association). By W. H. J. Vernon., B.Sc. London: The Faraday Society. [Price 7*s.* 6*d.* net.]

An Introduction to the Practice of Civil Engineering. By E. E. Mann, M.Sc. London: Macmillan and Co., Limited. [Price 7*s.* 6*d.* net.]

Factory Costing. A Text-Book for Students. By H. H Emsley, B.Sc. London: Constable and Co., Limited. [Price 7*s.* net.]

Population and the Social Problem. By J. Swinburne, F.R.S. London: George Allen and Unwin, Limited. [Price 15*s.* net.]

Lehrb Puch der Technischen Physik. art I. *Technische Mechanik starrer gebilde.* Chapter I. *Mechanik ebener Gebilde.* By Dr. Ing. Hans Lorenz. Second edition. Berlin: Julius Springer. [Price 4.30 dollars.]

Technical Costs and Estimates. By Andrew Miller. London: Gee and Company (Publishers), Limited. [Price 10*s.* 6*d.*, post free.]

Aeronautical Research Committee. Reports and Memoranda. No. 888. *Tests on a Large Aerofoil of R.A.E. 15. Section.* By L. F. G. Simmons, B.A., A.R.C.Sc., and E. Owen, B.Sc., A.C.G.I. [Price 6*d.* net.] No. 897. *The Lift and Drag of a Standard Bristol Fighter Aeroplane.* By the Aerodynamics Staff of the Royal Aircraft Establishment. [Price 4*d.* net.] No. 898. *An Experimental Test of the Prandtl Correction for Tunnel Wall Interference.* By W. L. Cowley, A.R.C.Sc. and L. J. Jones. [Price 3*d.* net.] No. 901. *Theoretical Relationships for a Biplane.* By H. Glauert. [Price 9*d.* net.] London: His Majesty's Stationery Office.

The Birth and Development of the American Submarine. By Frank T. Cable. New York and London: Harper and Brothers. [Price 12*s.* 6*d.*]

Sailing Ships Models. A Selection from European and American Collections with Introductory Text. By R. Morton Nance. London: Halton & Truscott Smith, Limited. [Price 3*l.* 13*s.* 6*d.*]

Wireless Possibilities. By A. M. Low. London: Kegan Paul Trench Trubner and Company, Limited. [Price 2*s.* 6*d.* net.]

Hutte. Taschenbuch für Betriebsingenieure. Second edition. Berlin: Wilhelm Ernst and Sohn. [Price 27·30 Swiss francs.]

Association Suisse de Propriétaires de Chaudières a Vapeur. 55me Rapport Annuel, 1923. Franenfeld: Huber and Company.

25-ton Electric Level-luffing Crane: Addendum.—With reference to our description of the crane under the above heading on page 104 of our issue dated July 18, 1924, we are informed that this crane was manufactured under the supervision of Messrs. Humby and Partner, Consulting Engineers, of 13, Victoria-street, Westminster, London, S.W.1.

THE DEVELOPMENT OF THE ST. LAWRENCE RIVER FOR POWER AND NAVIGATION.*

By R. S. LEA, M.Inst.C.E.

THE boundary line between Canada and the United States passes through the Great Lakes and their connecting rivers, and down the St. Lawrence to Cornwall, whence it continues eastward along the 45th parallel of latitude. Below Cornwall, the river is wholly within Canadian territory.

The St. Lawrence River, so-called, flows from Lake Ontario to the Gulf of St. Lawrence, a distance of about 600 miles, though its drainage area, which includes the entire basin of the Great Lakes, extends almost to the middle of the Continent. It is made up of three stretches which are very different in character. The first 60 miles, from Lake Ontario to Prescott, in which the current is very slow and the fall almost imperceptible, may be regarded as an extension eastward of the lake. It is generally deep, in some places over 100 feet; and as the minimum depth of the channel is 30 ft., only a small amount of dredging, to remove a few projecting shoals, is required to provide for 30-foot navigation.

The lower stretch, from Montreal to the Gulf, is tidal for nearly its entire length of upwards of 400 miles. From Montreal to Quebec City, a distance of 160 miles, it averages about 2 miles in width, except for a shallow expansion about 7 miles wide and 30 miles long, known as Lake St. Peter. This lake is worthy of notice because of its effect in shortening the season of navigation to Montreal both in spring and fall, a point which will be referred to later on. The channel has been deepened where necessary from time to time, until at present a depth of 30 ft. at ordinary low water has been provided. It is proposed to continue this work until a minimum low-water depth of 35 ft. has been secured.

In the third or intermediate stretch of 120 miles, Fig. 1, the river falls from about Lake Ontario level at Prescott to harbour level at Montreal, through a total height of some 225 ft. It is with the projected development of this portion of the river that the present paper principally deals, because many of the works, including the necessary river improvements, can be utilised for the joint purposes of navigation and power, the cost of such work being divided, with mutual advantage, between the two projects. The whole stretch, including the rapids, is navigated down-stream by passenger steamboats of 6 or 7-foot draft, and 14-foot navigation is provided for in both directions by a system of Canadian Government Canals around the rapids, which has been available for many years as indicated in Fig. 2. Power has also been developed at different points along the river to the extent of about 350,000 h.p., partly in a small way in connection with the Canals, but mainly in three or four plants which derive their power by diverting for themselves a portion of the flow of the river. An aeroplane view of the latest and largest of these, the Cedars Rapids plant, with a capacity of about 200,000 h.p. under a 30-foot head, is shown in Fig. 3, which indicates the general method of development. An interior view of the same plant is shown in Fig. 4. Each of the 18 units has a capacity of nearly 11,000 h.p.

The large-scale schemes which have been proposed within recent years, have been either (*a*) by certain power interests for the primary purpose of water power development on a scale necessitating the utilisation of the flow of the whole river, with provision for present and future navigation requirements, or (*b*) as a Government scheme for securing deep-draft navigation sufficient for ocean-going vessels, with the incidental creation of opportunities for the development of power. The second scheme is part of a more extensive undertaking, to enable ocean shipping to reach the head of the Great Lakes. It has already been investigated and approved as a whole by the International Joint Commission of Canada and the United States, which is a permanent body empowered by treaty to deal with all questions arising out of the use of boundary waters; and it is being further studied at the present time by representatives of the Governments of the two countries. From either point of view the works proposed are of exceptional magnitude and importance, the minimum ultimate depth proposed for the locks and navigation channels being thirty feet, and the total power when fully developed amounting to from four to five million horse-power, with individual plants having capacities of from 600,000 to 1,500,000 h.p.

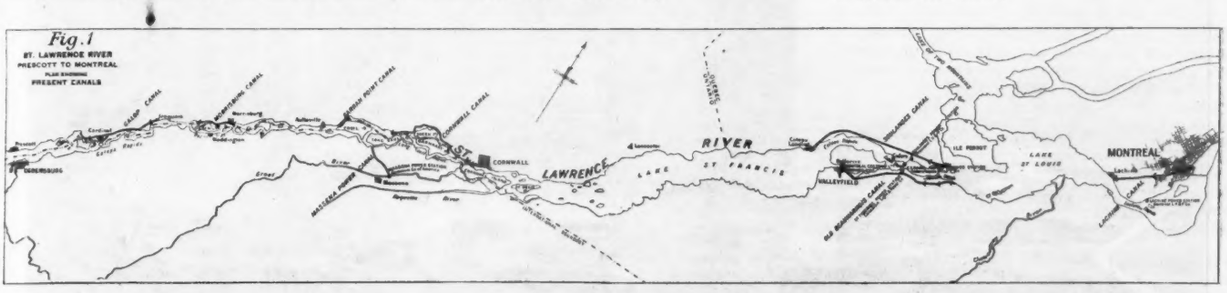


Fig. 1

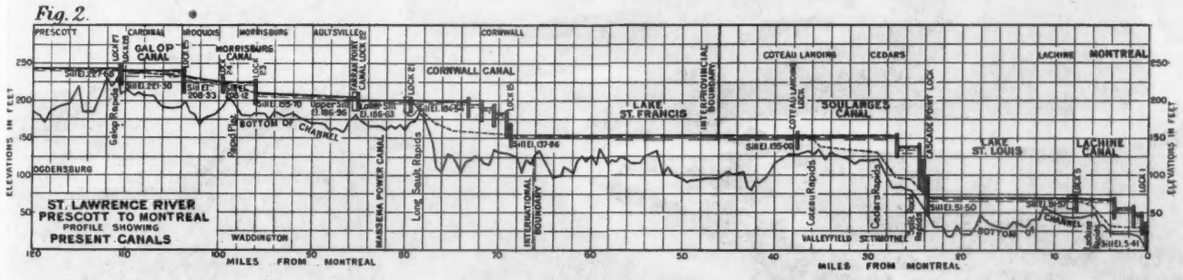


Fig. 2.

It will be convenient at this point to refer briefly to certain interesting, and in many cases unique, characteristics of the Upper St. Lawrence, which have an important bearing on the design, construction, and operation of the development works.

Uniformity of Flow.—This "power reach" of the river is not a river at all in the sense that its discharge is directly dependent upon the precipitation on its adjacent drainage area. The watershed of the entire basin of the Great Lakes, including the Lakes themselves, down to the head of the first rapids where the river virtually emerges from Lake Ontario, amounts in round numbers to 300,000 square miles. From this point down to its junction with the Ottawa, the tributary drainage area of the river is so small as to be negligible. Hence, for all practical purposes, the "power reach" may be regarded as nothing more than an overflow channel for Lake Ontario, and, therefore for the whole system of the Great Lakes, which constitute a system of enormous natural storage reservoirs whose combined surface area is 95,000 square miles, or nearly one-half that of the tributary land whose run-off they serve to regulate.

Of the total drainage area just referred to, about one-ninth is directly tributary to Lake Ontario, whose main supply flows into it through the Niagara River, which is subject to the natural regulation of its own storage and that provided successively by the Lakes above. Lake Ontario itself, with its 7,500 square miles of surface, provides sufficient storage capacity to receive the entire average inflow from the Niagara and the run-off from its own watershed, with a rise of a little over one inch per day, even with the discharge down the St. Lawrence entirely stopped.

The outflow from the lake is controlled by a ridge of rock crossing the bed of the river about 5 miles below Prescott, which acts as a submerged weir with an average depth of water upon it of about 15 ft. Hence, the discharge of the St. Lawrence is directly governed and measured by the elevation of the water surface of Lake Ontario, and the relation between the two has been very accurately determined by a long series of measurements and observations.

The resultant effect of the combination of conditions above referred to, in producing uniformity of outflow, is shown by the records and observations of nearly 65 years. The average recorded discharge of the river during this period is about 247,000 cub. ft. per second, which is however, considerably less than the true average because of the diversion, during the last 20 years or so, of an unknown quantity of water from Lake Michigan into the Mississippi through the Chicago Drainage Canal. At the present time this is estimated to be about 10,000 second feet, and as a result, there is a serious reduction in level in all of the lakes and river channels from Lake Superior to the Lower St. Lawrence. In this whole period the highest and lowest recorded (monthly mean) elevations were 248·95 and 243·41 respectively, or an extreme range of about 5½ ft. The corresponding change in the volume of flow was from 193,000 to 320,000 second-feet, equivalent to an average increment of discharge of 22,700 second-feet per foot rise in lake level. It is not quite uniform, but for the greater part of the time a change of 1 ft. in lake level will cause a change in the river discharge of from 22,000 to 23,000 second-feet.

Briefly summarised, the mean range of level over the whole period is less than 2 ft.; the range in any one year is rarely as much as 3 ft., and has been less than 1 ft.; and for years at a time has varied between 1 ft. and 2 ft. Translated into terms of discharge this means that on the average, and for the greater part of the time, the rate of discharge in any one year varies less than 10 per cent. either way from the average of that year; that the average discharge in any year seldom differs by more than 10 per cent. from that of the preceding year; that in the worst single year the minimum is about three-quarters of the maximum; and that for the whole period the minimum is six-tenths of the maximum. The fluctuations of river level follow closely those of the lake, the range being at some points a little more and at others a little less, depending upon local conditions as to cross-sectional area, slope, &c.

Such natural uniformity of level and flow is, of course, never even approached in any other river, whether subject to artificial regulation or not, and, indeed, would be extremely difficult to attain in any artificial channel, however elaborate the system of control. In this respect the St. Lawrence stands absolutely alone, and always will.

For purpose of comparison, reference may be made first to the Ottawa, which, next to the St. Lawrence, is the largest river in Eastern Canada, in which, as rivers go, there is a high degree of natural regulation; and, second, to the Susquehanna in Pennsylvania, which is a river subject to great fluctuations of flow. In the former the discharge varies from a minimum of about 10,000 second-feet to a maximum of 250,000 second-feet, with an ordinary flow of 16,000 to 18,000 second-feet; in the latter the range is from a minimum of 2,400 to a maximum of 550,000 second-feet, with a frequent high water discharge of over 300,000 second-feet.

It is also interesting to note that the changes in

* Read before Section G of the British Association at Toronto, on August 8, 1924.

discharge from one month to another, and often for much longer periods, could not be detected by an actual measurement. The canal gauges, however, have had their readings carefully related to the discharge by long series of accurate observations carried out by both the Governments of Canada and the United States. Hence, from most of them the river discharge can be determined at any time far more accurately than it could be obtained by any single measurement, however carefully made. As they have been read continuously since 1860, they furnish data both as to discharge and slope, of the greatest possible value in detail studies in connection with various hydraulic problems arising out of the proposed development. These gauges have been supplemented by many others, set up for this special purpose, and a great number of measurements and observations have been made, giving interesting and valuable information in connection with the hydraulics of the river.

Volume.—The fact that the total drainage area of the St. Lawrence at its mouth is nearly 500,000 square miles, places it at once among the large rivers of the world, although it is far from being the largest. The watershed of the Missouri, for example, is 528,000 square miles; of the Mississippi, 1,245,000 square miles; and of the Nile, 1,500,000 square miles. The Upper St. Lawrence watershed is only 300,000 square miles, yet so far as its low water flow is concerned, it ranks among the largest, and it is probably correct to say that its dependable flow is incomparably greater than that of any river in existence which is adapted to power development. There is no need, therefore, to dwell further upon the unique position of the St. Lawrence among rivers in respect to volume and dependability of flow.

Regulation.—Remarkable as is this regularity of flow, it can be easily improved, and many important advantages thereby secured. It is quite feasible, and indeed it is an essential feature of the proposed development of the river, to control the discharge at the uppermost dam so as to keep it within extreme limits of 210,000 and 280,000 second-feet. This will have an important effect in diminishing the quantity of channel excavation necessary to secure suitable navigation velocities at all points along the river, and to utilize the available fall for power to the greatest extent practicable. It will also benefit navigation in the lower river by maintaining a greater and more uniform depth in Montreal Harbour and in the Ship Channel below, and in considerably lessening the excavation necessary to secure the proposed 30 ft. depth at low water. By reason of the slow response of the level in Lake Ontario to any change in the supply, even when the run-off from the local watershed is excessive, it is not difficult to devise a reliable schedule of operations by which the regulated flow for each month will depend upon the records of the preceding month. Such a system of regulation has been worked out and, tested by the records of the last 64 years, it will, while restricting the maximum elevation of lake level to its present height, maintain a mean level 1 ft. higher than the present mean, and a minimum level 2 ft. higher than under present conditions. It will also provide an ample margin of storage always available for flushing ice and other contingencies.

Physical Features.—Throughout the "power reach" of the river between Prescott and Montreal, the river flows in a north-easterly direction over, rather than through, a district composed of glacial drift, largely boulder clay, underlaid by compact rock. As this stretch of the river has only been in existence, geologically speaking, for a comparatively short period of time, it has had no time to wear out anything in the way of a well-defined valley for itself; and as its maximum discharge is only fractionally greater than its ordinary flow, its channel approximates the dimensions of an artificial canal intended to carry a more or less unvarying volume of water. With low banks, its general width averages rather less than a mile, and its mid-depth varies generally between 35 ft. and 50 ft., being shallower, of course, in the rapids. Its steady flow and entire freedom from suspended matter, abrading or otherwise, as it flows out of the lake, has resulted in an extraordinary condition of permanent stability of banks and bed. The territory across which it flows has a slight northward slope from the Adirondack Mountains in northern New York, towards the Ottawa Valley, so that, especially in the upper half, the Ottawa River divide is never far from the St. Lawrence, and such tributary drainage area as there is, is on the south side of the river.

In the direction of flow, however, the land falls more rapidly in a series of three main steps or terraces, with comparatively level benches between. These terraces intersect the river, in a generally north and south direction, at the Long Sault Rapids, at the rapids above Lake St. Louis, and at the Lachine Rapids near Montreal. Down as far as the head of the Long Sault, a distance of about 30 miles, the fall of 40 ft. or so takes place more or less gradually, and to the foot of these rapids the profile of the adjacent land on either side closely follows that of the river.

As a result of these topographical conditions, the total fall takes place in three distinct reaches, separated by the river expansions of Lake St. Francis and Lake St. Louis which occupy the intervening benches. (See Fig. 2). These reaches extend, (1) From the head of the Galops (the first rapids) to the foot of the Long Sault; (2) From the head of the Coteau Rapids to the foot of the Cascades; (3) From the head of the Lachine Rapids in Lake St. Louis to Montreal Harbour.

In the upper reach from Prescott to Cornwall, a distance of nearly 60 miles, there is a total fall of a little over 90 ft. About half of this takes place in the Long Sault and the remainder in Farran's Point, Rapide Plat, and Galops Rapids, and in the swiftly flowing intervening stretches of the river. Between 80 ft. and 85 ft. of this fall can be utilised for power development. Between Lake St. Francis and Lake St. Louis, in a distance of about 15 miles, there are three rapids—the Coteau, Cedars and Cascades, with a total fall of about 82 ft., of which about 78 is available for power. Between Lake St. Louis and Montreal Harbour the total fall, including the Lachine Rapids, is about 45 ft., and of this only about 35 ft. can be developed for power at a reasonable cost, under present down-river conditions.

The land bordering Lake St. Francis and Lake St. Louis is so flat that it is impracticable to raise the water level above the present maximum. The only improvement, therefore, to be made in these lakes, in connection with navigation, is a moderate amount of dredging here and there where necessary for the deeper draft proposed, and no further reference to them would be required except for the difficulties they give rise to, in connection with the operation of the power plants during the winter.

In the upper stretch as far down as Cornwall, the land adjacent to the river, especially on the south side, has such a pronounced slope in the direction of flow that the tributaries tend to follow a course parallel to, and at no great distance from, the river itself; so that, towards the lower end it is impossible to raise the river level to any considerable extent, without extensive lateral dams and dykes to prevent overflow into its own tributaries which enter it below the Long Sault. A large number of deep borings have been made at different points along the river to determine the position and character of the underlying rock, which is never exposed except in the vicinity of the crest of the rapids. In every case sound bed-rock has been found particularly well adapted to provide solid and impervious foundations, and for the most part at convenient depths. The steady and dependable character of the flow eliminates the construction difficulties due to sudden freshets, usually met with in river work. It is also of course, of the greatest value in connection with the operation of the works. On the other hand, this very constancy of flow gives no opportunity to take advantage of periods of low water to instal cofferdams and do other early construction work; and at the stations selected for certain of the dams and power houses there is difficulty in finding room for the necessary diversion of part of the flow during construction. The development of such a large flow under

Fig. 3. Aeroplane View of the Cedars Rapids Power Plant.

the moderate heads available, requires power houses of unusual dimensions and capacities; and, on account of the great depths, high velocities, and ice effects, the placing and maintaining of some of the coffer dams will involve work of considerable magnitude and difficulty.

Winter Conditions.—From the foregoing it is obvious that as regards the flow in the open water months, the conditions in the St. Lawrence for constructing or operating a power plant or navigation system are almost ideal. During the winter season, however, this is often by no means the case. Ice troubles are common enough in all Canadian rivers, but with a river whose regular winter flow is ten to twenty times that of any of the other large power rivers of the country, when it practically ceases. Ice of a different kind, however, continues to form in the open water stretches, throughout the winter. Frazil ice forms in open water during periods of intense cold, particularly at night and in cloudy weather. This is the local name for a kind of ice which forms at the surface of slightly under-cooled water, especially when agitated. It occurs as fine spicules or detached crystals which are disseminated more or less throughout the body of the water by its motion, and which never freeze together to form sheet ice. Anchor ice forms on the bottom in clear cold weather, and when the conditions are favourable to terrestrial radiation. In the rapids of the St. Lawrence both kinds of ice form very readily even when the weather is only moderately cold. In

FIG. 4. INTERIOR OF CEDARS RAPIDS POWER STATION.

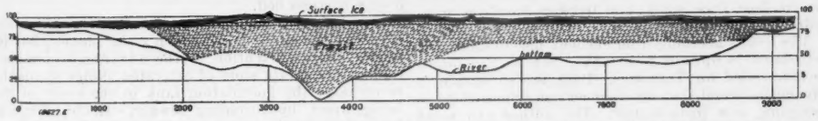


FIG. 5. CROSS-SECTION OF ST. LAWRENCE RIVER BELOW CASCADES RAPIDS SHOWING ACCUMULATION OF FRAZIL.

and as great or greater than the flood flow of most of them, and where, quite apart from the rapids, mid-channel velocities run from 5 ft. to 10 ft. per second, the difficulties from ice are also on a much greater scale and often of quite an unusual and complex character. As a matter of fact, ice is the crux of the problem of power development and operation, especially where the flow of the whole river is involved.

The upper river as far down as Prescott usually freezes over early in the winter and remains so till spring, when the ice melts in place, or comes down in such a disintegrated condition that it can be handled without difficulty. Below Prescott the river nowhere freezes across except in the expansions of Lake St. Francis, Lake St. Louis and Lake St. Peter, and if it were not for them it would remain open throughout to tidewater, and the period of navigation to Montreal would be considerably lengthened at both ends of the season. A large field of ice may bridge the open channel, but this has only taken place with serious effect once in eighteen years in the stretch above Montreal, and could easily have been prevented or dislodged if the proper measures had been taken. In the tidal portion of the river above Quebec, this is more difficult, but not impossible.

These lake expansions freeze over early, while the main channel from above the Galops to below the Long Sault Rapids remains open. A considerable area of bordage ice forms in the bays and subsidiary channels, and where slack water and eddies occur in the lees of the islands. Beginning early in December this ice, unless interrupted by thaws accompanied by high winds, gradually extends outward, encroaching upon the main channel till a point is reached where the surface velocity is from 2 ft. to 3 ft. per second, bright sunshine and with rising temperature the anchor ice loosens its hold on the bottom and rises to the surface, often in large quantities. Fragments of bordage ice detached by winds and currents, and drifting snow, add intermittently to the floating burden of anchor ice and frazil. At one time, ice of this kind gave considerable trouble in the operation of power plants by adhering to and blocking the racks and runners, but with the large capacity single runner vertical wheels of the larger installations, and with greater experience in the design and location of these plants, these difficulties have been practically eliminated. It may, therefore, be said generally, and of the St. Lawrence particularly, that it is in the river channels above and below the plants that the principal difficulties with ice are likely to be met with. Where the river can be kept open this slush ice is therefore of minor importance, but when it meets an ice cover as at the head of Lake St. Francis or Lake St. Louis, it is either drawn under by the current or, where this is not sufficiently strong, it builds back or "packs" upstream. In the former case it tends to rise and adhere to the under side of the ice cover, especially when it reaches a point of lower velocity. There it accumulates in great masses called "hanging dams," sometimes to a depth of 60 ft. or more (see Fig. 5). The jams thus caused raise the level and back the water up on the rapids next above. When the ice packs it forms a very rough and irregular cover of tilted ice cakes, masses of anchor ice and frazil, which greatly restricts the flow, and which in itself at once causes a much steeper slope and a consequent rise in water level. The ice cover in the Ship Channel between Lake St. Peter and Montreal is always formed by the packing of the ice.

Jams caused by these "hanging dams" form in the river opposite Montreal sometimes to a height of 16 ft. or 18 ft., and back the water up on the Lachine Rapids just above. Similar jams form at the head of Lake St. Louis, but not to the same extent, though one year the water rose as much as 11 ft. above normal level. More serious jams occur at the head of Lake St. Francis, and in the river channels upstream to the Long Sault Rapids, where a rise of 15 ft. is not unusual, and where in 1918, at the foot of Barnhart Island, the site of one of the proposed power plants, the water rose 27 ft. above summer level.

These are the results of ice jams as they exist at present, and where practically nothing has been done in the way of prevention or protection, except at Montreal. Considerable study is being given to these problems, and there is no doubt that much can be done to improve the conditions by taking measures and carrying out works which will tend to decrease the jams and to assist the river in its natural tendency to keep itself clear.

(To be continued.)

THE PART WHICH BIO-AERATION MAY YET PLAY IN PURIFYING SEWAGE.*

By JOHN D. WATSON, M.Inst.C.E.

SEWAGE bacteria beds built in the form of contact beds only fifteen years ago are now, in England, being replaced by the treatment called by Dr. Fowler "Activated Sludge," and by Mr. Haworth "Bio-aeration." This method reduces very greatly the area needed for installation, and it has the merit of greater freedom from smell than any other process hitherto adopted.

The name Activated Sludge has come to be associated with the air-blowing process, and Bio-aeration with mechanical agitation. The flocculation process essential to the success of both is very much the same, although brought about in different ways. The gelatinous film is generally believed to be the real seat of purification. Whether it surrounds the media in bacteria beds or creates the floc in a tank, it is brought into intimate contact with both air and sewage, either as the result of mechanical agitation or of blowing air through the liquid. The author looks favourably upon both methods, and thinks that so long as the principles laid down by Fowler, Arden and Lockett are adhered to, the method of carrying on the process may vary within wide limits. In one case the site available for constructing and actuating a purification plant may be better suited for the employment of deep flocculating channels in which the mixing is done by compressed air, and in another case the site may be more suitable for wide shallow channels using gas, oil, or electricity as a motive power for mechanical agitation. The responsibility rests upon the consulting engineer (who should not be interested in one patent more than another) to recommend the best and cheapest method for the purpose, always bearing in mind that even the best designed plant is dependent upon good management for good results.

Where suitable land of ample area is available within a reasonable distance of a great town—which is not common—land irrigation may still claim the premier position, not only as a natural and reliable method of purifying sewage, but as one which almost defies mismangement. It should be recognised quite frankly, however, that in dealing with the wastes of great cities which in themselves are more or less artificial, the systems of purification are by their very size bound to depart from Nature's methods, but that very departure from Nature may supply a felt want. For instance, it is now possible to provide small units of purification plants in populous districts without creating nuisance in the vicinity.

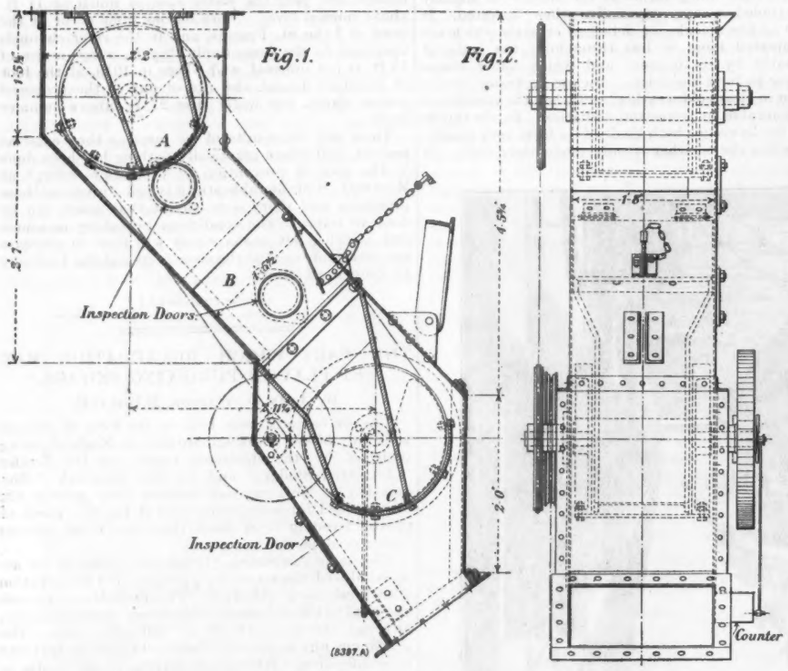
The contact bed, it must be admitted, has had its day, but where it has been built and continues to function, it may be greatly improved if it is worked in conjunction with a bio-aeration plant. The percolation bed is reliable in its results; it is comparatively easily accommodated as regards site, if the area required is limited; it is cheap where suitable building material is obtainable, and it is not costly either to maintain or to manage. But it may give off objectionable odours, it may breed flies and mosquitoes, and its surface may clog with colloidal matter not readily oxidisable. All these are serious objections, but, nevertheless, the percolation bed is a permanent institution, capable of performing good work. If, however, it is made to work in harmony with bio-aeration, it is sure to produce a more efficient and generally more economical plant than either the one or other separately worked.

Until 1923 all the activated sludge and bio-aeration

* Read before Section G of the British Association at Toronto, August 13, 1924. Abridged.

COAL MEASURING APPARATUS AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. EDGAR ALLEN AND CO., LIMITED, ENGINEERS, SHEFFIELD.



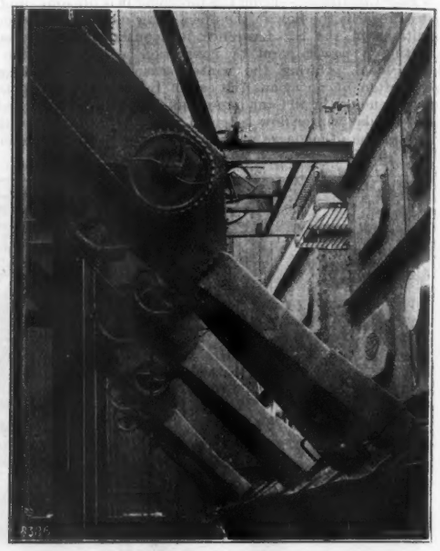


Fig. 3.

plants had been built to perform the complete purification process, and with very few exceptions (*e.g.*, Worcester, Mass., where the volume of inhibitory trade waste was inimical to the process) they were successful as regards the production of a good effluent, but they have all failed to deal with the sludge problem, and they all produced an increased volume of sludge containing not less than 99 per cent. of water. At one time the production of this sludge, which admittedly contained 6 per cent. of nitrogen, was lauded as one of the advantages sought, but this attitude appears to have become less popular. In any case, the disadvantage associated with it more than offsets the advantage. The author affirms that it is a mistake to produce this highly nitrogenous sludge merely to get rid of it. To necessitate reversion to land treatment merely to utilise sludge cannot ordinarily be profitable. The aim of the engineer in designing the plant should be to limit the production of aqueous sludge to what is absolutely required for carrying on the bio-aeration process. It will be found that, as compared with the bulk of liquor in the flocculation tank, the organic matter required for complete nidification of the living organisms need not be more than 5 per cent. of the volume, provided always that every particle is brought to the surface of the liquid and exposed momentarily to the air not once or twice but many times, as in the air-blowing method of treatment. If only 5 per cent. or less is needed to carry on the process, as the author has found after prolonged trials on a large scale, it is obvious that the ordinary mechanical methods of abstracting solids from sewage need not be interfered with, because there will be more organic matter left in the sedimentation tank effluent than is needed to build up the nidus required to produce successful flocculation.

Without going fully into the question of sludge treatment and disposal, it is enough to say that sludge obtained from sedimentation tanks usually contains no more than 90 per cent. water, and that activated sludge on the other hand generally contains 99 per cent. of water. The volume of sludge to be treated in the latter case is, therefore, enormously greater than in the former. At Birmingham, where the sewage from a population of one million people is treated, the sludge eliminated from the liquid is changed by bacterial digestion, following principles laid down by Drs. Travis and Imhoff, into a much smaller volume of inoffensive residuum. This residuum, which is used as an organic base in the preparation of a fertiliser, yields a reasonable return. Apart from the unwisdom of building up a great volume of aqueous sludge which has to be de-watered, it is well to bear in mind the undesirability of employing motive power to move solids which are not essential to the process. In judging the relative merits of several different types of installations by initial cost, bio-aeration should be accorded the first place, but when running costs and interest on capital outlay are added together; and, compared similarly with a bacteria bed installation, it will be found that the latter is the cheaper, unless indeed motive power can be obtained for less than one penny per unit of electrical energy, and restricted in use to not more than 30 brake horse-power per 24 hours per million gallons treated. Apart from questions of cost, however, there are at least two factors in the comparison which are in favour of the bio-aeration plant, and those are freedom from smell, and freedom from the mosquito and fly nuisance.

The results accruing from efficient flocculation plus settlement in upward flow tanks, such as the author recommended for Toronto in 1909, are so certain in preventing smell that no engineer can ignore them in designing new installations. The author can recall several cases where bacteria bed installations were proposed for populous districts, and where they would probably have been efficient but for the smell and the fly nuisance associated with them. One conspicuous case was at New York in 1912 when the author advised the Metropolitan Sewerage Commission not to think of erecting 1,000 acres of bacteria beds on Barren Island in view of the smell which might have been caused. In bio-aeration we have a powerful ally capable of combating successfully just such difficulties.

However objectionable malodours arising from septic sewage may be, it is difficult to induce a local authority to spend money to cure a nuisance which recurs only at long intervals, but the knowledge that it is now possible to do so will change the attitude of the average citizen towards questions of this kind, and place local authorities in a different position as regards their responsibility in the eyes of the law.

It is difficult to exaggerate the importance of the discovery that it is possible to reduce by about 60 per cent. the amount of impurity in a tank liquor after one hour's agitation; not only does that limited treatment deprive the liquor of those compounds which produce smell, but it all but frees it of its colloidal matter which is the bugbear of all who are responsible for the management of bacteria beds. The Birmingham experience proves that a bacteria bed is capable of oxidising two or three times as much flocculated liquor as it can of sedimentation tank liquor, thus proving that by the help of bio-aeration, the bacteria bed may be reduced to a third of its normal size without impairing the quality of the final effluent.

The bio-aeration plant at Birmingham which was constructed on the author's advice two years ago emphasises several features of outstanding significance, when contrasted with typical Manchester and Sheffield plants, both of which combine in one operation the two essential features of the process. The Birmingham plant aims at separating the physical operations required to condition the gelatinous film or nidus, provide the air essential to the process, and effect efficient mixing of the sewage liquor and nidus. It has shown that the motive power necessary to provide air in some cases need not be more than 1 to 5 as compared with the power required for efficient mixing; this indicates one way to economise by better co-ordination of the mixing and aeration intensities. It has proved that it is very easy to remove objectionable smell-producing compounds from sewage before it is sprayed or otherwise distributed over the surface of a bacteria bed. It has proved also that by eliminating the colloidal matter from sewage, it is very much easier to oxidise it on a bacteria bed.

The design of the plant necessitates the provision of a reconditioning tank, which costs money, but it draws marked attention to the advantage of maintaining a separate store of activated sludge available to recharge the flocculation tank in the event of its being upset by incoming sewage, which everyone knows is liable to change as the result of rain falling or of sudden and unexpected rushes of inhibitory trade waste, both prejudicial to the emission of an unvarying effluent from a biological process. It has no doubt been inferred that the author does not espouse any mechanical form of air-blowing or agitation, for he is satisfied that the last word has not been said on that subject, nor can it be said that the scientific side of the question has been completely explored by the biologist and chemist, but he is sanguine that we have reached the stage of knowledge which under the direction of a wise Ministry of Health will induce a proud self-respecting people to demand better and cleaner rivers.

COAL MEASURING APPARATUS.

We illustrate in Figs. 1 to 3 on the present page the dust-proof coal measurer complete with hopper and delivery shoots built by Messrs. Edgar Allen and Co., Limited, Sheffield. Fig. 3 shows three measurers installed at an electric power station. An example of the appliance is to be seen at the British Empire Exhibition. Messrs. Edgar Allen manufacture this apparatus in three sizes, having a capacity of 2 cwt., 3 to 3½ cwt. and 4½ to 5 cwt. Figs. 1 and 2 illustrate the 3 to 3½ cwt. apparatus. The measurer comprises two balanced valves, marked A and C in Fig. 1, connected together by a chain working over sprocket wheels, fitted to the valve spindles. The position of the valves is set so that when one is open the other is closed. The coal, or other material to be measured, is admitted through the top valve A until the chamber B is full, when the top valve A is closed and the bottom valve C is opened to allow the coal to pass to the boiler hopper, or the other material to be delivered where required. A regulating plate is provided (Figs. 1 and 2), whereby the quantity of material delivered into the chamber B can be adjusted. A self-registering counter

fitted to the side of the apparatus is operated by a lever connected to a gear wheel working the valves. By this means every charge is recorded and the quantity of material which has passed through the measuring box can be ascertained at any time.

ELECTRICITY IN COAL MINES.*

By ROBERT NELSON.

COAL-MINING was an old-established industry with many fixed traditions long before electricity made its appearance, and the electrical engineer had, in fact, to thrust himself and his equipment, almost uninvited, into the field and insist upon taking a more or less prominent part in the further development of the industry. Some education of the reluctant mining engineer was necessary and some important problems had to be solved before the mining engineer and the electrical engineer appreciated each other's aims, but a practical and satisfactory solution was gradually evolved, based upon the requirements of coal-mining as the coal faces receded from the shafts and upon the limitations imposed by conditions on the one hand, and the character of the electrical plant available on the other. The object of this paper is to indicate the obstacles to the use of electricity in mines which have been overcome, partly by what is often called "horse-sense" and partly by research and experiment.

The convenience of using electricity for power and light underground was soon recognised. So far as can be ascertained the first electric motor to be set to work below ground in a coal mine was at Trafalgar Colliery, Drybrook, Gloucestershire, in January, 1883. Thirty years later—that is to say, in 1913—the total horse-power of electrical plant in use underground was 316,667, but the next ten years saw this last-mentioned figure a good deal more than doubled, for by the end of 1923 the total horse-power of electric motors installed below-ground had reached 753,138, in itself a moderate figure having regard to the total horse-power of all forms of motive power in use in the mines, but indicating a greatly accelerated rate of growth during recent years. There is no doubt that this increased rate of growth has been directly due to increased confidence in the safety of electricity, quite apart from its convenience and reliability and the improved design of the apparatus available. Electricity is the perfect medium for distributing power below-ground, practically and economically, but of immediate importance is the safety point of view, and in order that this aspect of the matter may be regarded in its true proportion it is here desirable to give the statistics of electrical accidents so far as these are available. Electricity is used for three main purposes in coal mines, namely: (1) motive power, (2) light, and (3) telephones and signals, and there are three classes of fatal accident for which the use of electricity below-ground may be primarily responsible, namely (1) explosion, (2) fire, and (3) shock.

Experience indicates two conclusions both of which are somewhat remarkable. The first is that, taken over a long period, electric shock has caused more than two-thirds of the deaths attributable to the introduction of electricity below-ground, and the second is that until a very neat and clean-cut research solved the problem in 1915, electric-signalling circuits in use at mines were at least as likely to initiate an explosion as the very much heavier current-carrying power and lighting circuits. The statistics for underground electric-shock accidents are given in convenient form in the table.

Triennial Period.	Deaths from Electric Shock Below Ground.	H.P. of Electric Motors in Use Below Ground at End of Each Period.	Deaths per 100,000 H.P. of Motors Installed.
1910 1911 1912	31	316,667*	9·8
1913 1914 1915	25	468,628	5·3
1916 1917 1918	12	548,592	2·2
1919 1920 1921	10	644,905†	1·7

* The figures in this column were first available at the end of the year 1912.
† The corresponding figure for 1923 has been given above as 753,138 h.p.

As regards the other dangers, namely, those of fire and explosion, such accidents as have happened have occurred at very irregular intervals, but taken over the whole period and confining the statement to power and lighting circuits, the sum-total of the loss of life under both heads has been about one-half of the total loss from electric shock. The striking improvement in the standard of safety as regards the risk of electric shock which the table shows has been mainly due to the common-sense application of improved methods in electrical distribution and the adoption of so-called "iron-clad" construction in apparatus used below ground.

From this summary it may be judged that the results are creditable to both mining and electrical engineers, and, not least, to electrical manufacturers. All the parties mentioned have contributed in their various ways towards the high degree of immunity from certain classes of accidents, which, with ordinary care, can now be attained. But before this position of comparative security was reached "Electricity in Mines" passed through a critical period. From early days down to those of ten years ago, in the then condition of affairs gloomy fears and predictions of disaster were frequently heard. If their views were correctly voiced by the Miners' Federation officials—and there is no reason to doubt that they were—the coal-miners individually strongly objected to the free introduction below-ground of "this new and mysterious agent." They feared not so much the risks of shock and fire as the risk of explosion, and their fears were far from being altogether unfounded. In a succession of mining disasters between 1909 and 1913 the electrical plant was, and not without reason, suspect, and it then came to be realised by those immediately interested that to discuss whether this agency or that was the cause of a disaster was in fact to condemn equally both agencies, whichever might ultimately have to bear the blame of guilt as the result of investigation. It was felt that to call for a decent minimum of precautions would not in this case relieve those concerned of responsibility, and that the risk of these sudden and appalling disasters demanded the wide adoption of every possible precaution that ingenuity and science could suggest. It will be remembered that in appraising the situation as regards fire and explosion the figure indicated refers to power and lighting circuits only. The further danger of sparks from signalling bells and wires was not at first generally realised, and if it can be said that the number of accidents *clearly* chargeable against the use of electricity below ground is, in all the circumstances, surprisingly few, nevertheless it should not be overlooked that in the case of the greatest disaster in the history of British coalmining, the electric signalling circuits were not free from well-founded suspicion. This explosion occurred at Senghenydd Colliery, South Wales, on October 14, 1913. It is interesting to note in passing that the challenge of this situation was at once accepted. Following a line of investigation which is of the genus of Davy's classical experiments preceding his invention of the safety-lamp, Professor W. M. Thornton, of Newcastle, enunciated and proved a safe and satisfactory solution of the problem presented.

The point it is here sought to make is that the outlook of electricity in mines was at one time doubtful. Now, on the contrary, the position is quite secure. Nothing is heard of the miners' opposition of ten or twelve years ago, and mining engineers in increasing numbers are beginning to regard the still comparatively new and the still mysterious agent as what in fact it is—the right arm of mining development. In the succeeding paragraphs it is the intention briefly to outline the scientific and other investigations which have contributed to a situation which, *quâ* electricity, can be regarded as satisfactory in view of what has been done and—so far as can be seen at present—in view of the comparatively little that remains. It has been said that diminution of the risk of electric shock required no more than the common-sense application of well-established principles of construction. The same applies in a large measure to diminution of the risk of underground fire. It was in connection with the elimination of the risk of explosion that new and improved apparatus and scientific investigation and research found their opportunity.

The first investigation of safety problems below-ground with regard to the use of electricity was that of the German Firedamp Commission of 1881. This was really an inquiry preliminary to the then contemplated introduction of electricity underground, and explosive mixtures of pit-gas and air were ignited experimentally by electricity in various ways. The practical conclusion was negative. It was established that under the contemplated conditions of use and with the appliances then available, electricity could not be regarded as other than a potential, if not an active, danger. The early introduction of electricity below ground was made possible not so much by improvement of method and apparatus as by the efficiency of mine-ventilation, with the result that electricity could only be used below ground in early days where the conditions approximated to surface conditions. The plant in general use at that time below ground was plant designed for surface work. This surface plant was sometimes altered and adapted for use below-ground, but more frequently this was not done, and it was not until the early years of the present century that a serious attempt was made to investigate the conditions required to be met for safe working underground. In 1904 the Home Office appointed a Departmental Committee to inquire into the matter, and this committee must be given credit for having conducted a few tentative but inconclusive experiments. Later—that is to say, in 1906—the Mines Department of the Belgian Government conducted a series of experiments with motors of different types, and the conclusion reached was that the so-called "plate-ventilated" type of motor was safe to use in gaseous mines, but this conclusion did not receive general support. In Great Britain three great colliery disasters—those at West Stanley in February, 1909, Hulton in December, 1910, and Senghenydd in October, 1913—forcibly directed attention to prevailing weaknesses in connection with colliery electrical equipments. In a paper before the Institution of Mining Engineers in May, 1909,* following the West Stanley explosion—where the cables were at one stage the suspected cause—it was proposed to apply the then recently developed system of balanced leakage protection to colliery cables and to render switch-gear explosion-proof by means of wide metal-to-metal flanges. Both suggestions have since amply proved themselves in practice, though the first was merely an application to the distribution and use of electricity in coal-mines of an idea which had been developed in another field. Nothing was known at that time of the influence of the voltage and frequency of the current and the capacity and inductance of the circuit in relation to the ignition of firedamp by electric sparks. It was known that, generally speaking, electric sparks were dangerous, but there was no precise knowledge, and no attempt had been made to find the critical limits in respect of the quantities just mentioned. Professor W. M. Thornton, of Newcastle-upon-Tyne, had, however, been closely engaged in investigating the colliery explosions just referred to, and he subsequently entered alone upon the laborious task of measuring the current and voltage that just caused ignition, all the other factors—such as the frequency and inductance of the circuit, the percentage of firedamp in the explosive mixture, the metal of the poles, and the condition of turbulence or otherwise of the mixture, and so on—being systematically varied. This important research occupied Professor Thornton, first and last, over twelve or thirteen years. A list of his papers† on the subject of the limiting conditions for the ignition of firedamp and coal-dust and the influence of the presence of gas on the inflammability of coal-dust is in itself impressive, and I doubt whether his work has received from electrical and mining engineers the recognition which it richly deserves. As lately as January last Professor Thornton summed up the results he has attained before the Institution of Electrical Engineers in a paper entitled "Some Researches on the Safe Use of Electricity in Coal Mines," and he was able to make a very remarkable claim. Speaking of the beginning of his own investigation, he says, "The alternative to such an investigation is to wait for the event, hold an inquiry, and then act upon the finding. The cost in life and material of such a method is high, and so far as electricity is concerned need never be paid, for if the human element of carelessness could be for ever removed, to each possibility of electrical risk there is a simple and effective preventive." This claim is not based upon theoretical possibility but upon practical tests, and, having regard to its source, it is naturally in no degree an over-statement.

It has been said that a high standard of safety in respect of heavy-current machinery has been secured below-ground mainly by the application of common-sense methods of construction to the electrical plant, combined with the application of leakage current protective devices to mining conditions. The risk of open-sparking due to damage of an armoured cable protected by a leakage-trip is now so slight as to be

* Paper, abridged, read at the Empire Mining and Metallurgical Congress, held at the British Empire Exhibition, June 4, 1924.

* R. Nelson, "Electricity in Coal Mines," *Transactions of the Institution of Mining Engineers*, 1909, vol. xxxvii.
† W. M. Thornton and E. Bowden, "The Ignition of Coal-dust by single electric flashes," *Transactions of the Institution of Mining Engineers*, 1910, vol. xxxix.
W. M. Thornton, "The Influence of the Presence of Gas on the Inflammability of Coal-dust in Air," *Paper read before the British Association*, 1913.
"The Electrical Ignition of Gaseous Mixtures," *Proceedings of the Royal Society*, 1914, vol. xc, p. 272.
"A New Battery Signalling Bell," *Transactions of the Institution of Mining Engineers*, 1915, vol. l, p. 19.
W. M. Thornton and R. V. Wheeler, "Electric Signalling with Bare Wires," *Home Office Report*, 1916.
W. M. Thornton, "The Ignition of Gases by Hot Wires," *Philosophical Magazine*, 1919, vol. xxxviii, p. 613.

almost negligible, and the further condition that there should be present at the same moment a mixture of firedamp and air containing between 5·6 and 14·8 per cent. of firedamp—the limits between which firedamp is inflammable—makes the possibility of an explosion from this cause extremely remote. As new methods of protection and improved apparatus began to establish themselves the Home Office appointed a Committee to investigate the working of the regulations governing the use of electricity in mines—regulations which had been established in 1904—and to make suggestions for their improvement. Building upon the work of its predecessor this Committee recommended a revised code of regulations which in its results has been very successful. It was referred to in a recent paper before the Institution of Electrical Engineers as "the Reform Bill of Electricity in Mining so far as British practice is concerned." This code was established at the mines in 1912 and it has undoubtedly assisted materially in attaining the present relatively satisfactory position.

The work of Professor Thornton is directly applicable to the lighter apparatus in use below-ground, that is, to the cables and fittings for electric lighting circuits, to telephone and signalling apparatus and to all cables used in conjunction with such apparatus. It is now clear that greater risk attached to the use of apparatus of this character than was at first generally realised. The methods which have secured comparative immunity from accident with heavy-current machinery might clearly have been applied, though at considerable expense, to the lighter apparatus and this suggestion was seriously made,* but Professor Thornton's conclusions remove the need for the added expense whilst providing an improved technical solution of the problem. Briefly stated, Professor Thornton's method has been the method of experiment and I may here attempt to summarize the general character of his investigation. He has examined the electrical ignition of gas alone and of coal-dust alone and of mixtures of the two, with direct-current of varied voltage and with alternating-current of varied voltage and frequency. He has established the limiting electrical conditions under which ignition of coal-dust and firedamp may occur. His broad conclusions are that ignition by alternating-current arcs is more difficult than by direct-current up to about 1,000 volts, beyond which voltage they are much the same, and, as might have been anticipated, ignition, at low frequency is more difficult than ignition at high frequency. One important practical application of this series of experiments may be mentioned. At the standard periodicity of 50 cycles per second it requires a current of 25 amperes in a 50-volt circuit to ignite a mixture of methane and air. A lighting circuit on a 50-period 50-volt system could therefore be made to supply half-a-dozen lamps with an ample margin for safety under any set of conditions likely to be met with in practice below-ground. Such a result brings the effective lighting of in-bye roadways and even coal-faces within the region of early development, with important economic possibilities quite apart from improved safety conditions.

In connection with his work on signalling apparatus Professor Thornton has been associated with Professor R. V. Wheeler of Sheffield University. Professor Thornton first indicated the general lines of successful approach to the Home Office, and he subsequently communicated the results he had attained to the Institution of Mining Engineers. Meantime, in September, 1914, the Home Office appointed a committee, consisting of Professor Thornton and Professor Wheeler, and the author, to investigate the practical application of Professor Thornton's research. The author was unavoidably prevented from continuing the investigation, but Professor Wheeler and Professor Thornton submitted a report on the subject, which is a model from the point of view of a clean-cut and readily-understandable solution of the problem submitted for their consideration.†

The direct-current signalling bell used in mines is an improved form of the ordinary trembler bell with magnetically-operated make and break. Sparking occurs both at the point where the signal is made (either by means of a push-switch, or by bringing together bare galvanised iron wires running along the roadway), and at the trembler contact. Attention was forcibly directed to the danger of the sparks in signalling circuits at the inquiry following the Senghenydd disaster in October, 1913, and it was found that both sparks—that at the point where the signal is made, and that at the trembler bell—could ignite gas. What Professor Thornton proposed was to suppress the inductance voltage of every signal circuit at break by connecting across the ends of the magnet-winding a non-inductive resistance of value sufficiently low to act as a shunt. The magnitude of such a spark-damping resistance depends upon the inductance of the magnet-windings, but resistances from 10 to 20 times that of the coils are usual. Professor Thornton and Professor Wheeler showed that, so long as the pressure across the trembler contacts does not exceed 25 volts, a bell can be made to ring freely in the most explosive mixture of methane and air without any fear of igniting it. Another means of damping the spark at break is the use of a short-circuited winding connected in parallel with the coils. Alternating current bells have usually no make-and-break spark, but they have highly inductive windings, and the spark at the signalling point where the circuit is made and broken is dangerous unless suppressed. In this case the damping is effected by arranging between the wires a high resistance which is brought into circuit by a double contact whenever a signal is made. The net result is that "safety bells" are now available as well as safety lamps. The practical outcome of the whole series of experiments is that electric-lighting apparatus and cables, and signalling apparatus and cables, without armouring or any other form of protection, can now be specified so that inflammable gas shall not be ignited in any possible circumstances of their normal use.

Earlier in this paper, the view has been expressed that in the present situation few, if any, fresh fields of research remain unprospected. Experience may suggest an adjustment here and there, but practically everything is known about the requirements of safety in connection with the different types of apparatus in present use, and that any research in the immediate future will, or can, disclose results comparable with those I have tried to outline is extremely unlikely. Professor Douglas Hay and Mr. I. C. F. Statham recently gave an interesting account of investigations carried out in the Mining Department of the University of Sheffield into the flame-proof design of casings for electrical apparatus.* All kinds of apparatus were submitted for test—motors, controllers, switches, coal-cutters, gate-end boxes, and cable joint-boxes—and Professor Hay and Mr. Statham in the end were able to report as follows: "It is satisfactory to record that very few failures have occurred under test; in fact, with one exception, such failures as there were took place under abnormal conditions imposed to determine the limits of safety, so that failure was anticipated."

It is not held that no unsatisfactory mining electrical plant is now offered for sale, but it can, I think, be said that electrical manufacturers have amply proved their readiness to meet requirements, if and when these are clearly expressed by the coal-mining industry.

At the end of their paper Professor Hay and Mr. Statham sum up their views regarding the risk to be apprehended from the use of electrical mining apparatus at present available in these words: "With the continued improvement in the standard of design and maintenance of electric plant, it is obvious that in the future the risk of danger arising from the installation and use of electricity will be almost negligible. Side by side with this advance, there is also a steady improvement in the standard of ventilation in mines, and a progressive diminution of risk from the presence of coal-dust. It must be believed that the risk of failure of apparatus coinciding with the presence of dangerous conditions due to fire-damp and coal-dust will be remote, and this fact must tend towards an increasing use of electricity underground." I agree with them. The opportunity offered for future research with the object of securing greater safety in connection with the use of electricity in coal mines is at the moment almost non-existent. What is desirable is that knowledge already gained should be everywhere applied.

Portable X-Ray Equipment.—To render more convenient the employment of X-ray apparatus for the examination of welded joints and manufactured objects, such as automobile parts, rubber tyres, aluminium-alloy castings, aircraft structural details, &c., a complete equipment for radiography designed by Professor A. M. Low and Mr. D. Douet, has been mounted on a motor-car so that it can be transported easily and rapidly from place to place. Power is supplied by an alternator located over the bonnet of the car and driven by chain from the engine crankshaft, the current being passed through a step-up transformer to a Coolidge tube. The control gear, and the developing apparatus for the radiograms, are carried on the car, which thus forms a complete radiographic unit; it is, of course, equally suitable for medical work. Full particulars of the system can be obtained from Mr. J. C. Wilson, of Messrs. Portable Radiographs, 11, Ruvigny-gardens, Putney, S.W.

CATALOGUES.

Electric Fans.—A priced list of small electric fans for ventilating rooms in offices, factories, &c., is to hand from Messrs. Veritys, Limited, Aston, Birmingham.

Shears.—Mr. Henry Pels, 40, Great Marlborough-street, London, W. 1, has sent us a catalogue of shears in various sizes for the cold cutting of rounds up to 8 in. diameter.

Small Electric Motor.—A small electric motor weighing about 7 lb. and developing about ⅛ h.p. is illustrated in a catalogue received from the Metropolitan-Vickers Electrical Company, Limited, Trafford-park, Manchester.

Ball Bearings.—A range of ball bearings and roller bearings is listed, with particulars of sizes, loads, weights and prices, in a catalogue issued by the S.R.O. Ball Bearing Company, 115, Southwark-street, London, S.E.1.

Anti-Friction Metal.—A catalogue of "Eel" brand anti-friction metal for bearings, received from the makers, Messrs. Thermit, Limited, 155, Church-road, Battersea, London, S.W. 11, contains figures of hardness and running tests, and directions for casting.

Chemical Works Machinery.—Messrs. Manlove, Alliott and Co., Limited, Nottingham, have sent us a card illustrating some of the pressses, evaporators, dryers and other machines produced by them for the chemical and allied manufacturing industries.

Bearings.—Messrs. Hyatt, Limited, 56, Victoria-street, London, S.W.1, have issued two leaf catalogues showing their designs for toothed gear bearings, comprising axle bearings for worm, bevel, pinion and lay shafts, and internal bearings for compound and idler gears running on fixed shafts.

Sawing Machines.—A number of sawing machines with single and multiple blades are illustrated in some leaflets received from Messrs. Charles Wicksteed and Co., Limited, Stamford-road, Kettering. Centreing and bar-straightening machines, and tools for cutting and working boiler tubes, are also shown.

Boiler Mountings, &c.—A catalogue prepared for the British Empire Exhibition, and containing views of their works and particulars of high-pressure steam valves, safety valves, water gauges, steam pressure gauges, draught gauges, stop valves, reducing valves and mine-signal indicators, is to hand from Messrs. J. Hopkinson and Co., Limited, Huddersfield.

Thermometers.—A catalogue of thermometers with dials on which the temperature is indicated by a hand moved by a Bourdon tube has come to hand from the Cambridge Instrument Company, Limited, 45, Grosvenor-place, London, S.W. 1. The instruments are made in eight calibrations up to 550 deg. F., and with a variety of flange and screwed connections.

Electric Motors.—An illustrated descriptive catalogue of induction motors up to 22 h.p. at 1,500 r.p.m., with tables of dimensions and of outputs at various speeds, is to hand from the A.C.E.C. Company, of Brussels, whose London office is at 56, Victoria-street, S.W.1. We understand that, at the company's Brussels works, a production of these machines exceeding 1,000 a month has been attained.

Refrigerating Machinery.—A catalogue received from Messrs. Peter Brotherhood, Limited, Peterborough, contains a simple statement of the principles of the mechanical production of cold together with a detailed explanation of the machinery made by the firm for refrigerating, and also of some of the processes employed in the various industrial applications. Messrs. Brotherhood manufacture all the necessary plant, and will furnish particulars for any specific industrial installation on application.

Automatic Regulators.—The Steam Fittings Company, Limited, West Drayton, Middlesex, have issued two leaf catalogues showing some useful devices for the automatic regulation, by gas, water, oil, air or steam pressure, of valves, switches, dampers, &c., and suitable for working at distances up to 150 ft. Temperature regulators, and a fitting for geysers which shuts off the gas automatically when the water is turned off by hand and prevents the gas from being lighted until the water has been turned on, are also dealt with.

Oil Engines.—The medium-power oil engines made by Messrs. Tangyes, Limited, Birmingham, are illustrated and described in a catalogue recently to hand from that firm. The engines are of the cold-starting type, governed by variable admission of fuel, and normally consume residual or refined oils, but may be arranged for running on tar oils, alcohol, &c. They can also be made to consume liquid or gaseous fuels interchangeably. The lists of standard sizes give particulars of 13 single-cylinder engines ranging from 18 brake horse-power to 125 brake horse-power, and 11 coupled engines developing from 50 brake horse-power to 250 brake horse-power. All the engines listed can be supplied specially arranged for driving generators for electric lighting.

Christchurch Pumping Plant Tenders.—A call for tenders has been published in connection with the Christchurch (New Zealand) installation of electrically-driven pumping plants. Tenders close at noon on October 21. United Kingdom firms in a position to supply British-manufactured plant can obtain further particulars regarding this call for tenders on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, quoting reference A.X. 1220.

---

* R. Nelson, "Electricity: The Continuation of a short paper addressed to Colliery Managers," *Transactions of the Institution of Mining Engineers*, 1914, vol. xlvii, p. 115.

† R. V. Wheeler and W. M. Thornton, Home Office Report on "Electric Signalling with Bare Wires so far as regards the Danger of Ignition of Inflammable Gaseous Mixtures by the Break Spark at the Signal Wires" (1916).

* Douglas Hay and I. C. F. Statham, "Flameproof Design of Casings for Electrical Apparatus: An Account of Investigations carried out in the Mining Department of the University of Sheffield," *Transactions of the Institution of Mining Engineers*, 1924, vol. lxvii.

THE WORK OF THE FATIGUE PANEL OF THE AERONAUTICAL RESEARCH COMMITTEE.*

By Professor C. F. JENKIN, C.B.E., M.A.

SHORTLY after the war, the Aeronautical Research Committee appointed a panel to investigate the problem of fatigue in metals. It is not intended in this paper to give a complete account of the work done by that panel, but to describe the nature of the problem it is endeavouring to solve and the various lines of investigation which are being followed. The problem is not yet solved; the many interesting facts which have been discovered have upset the theories from time to time suggested without, at present, giving any certain guide as to where the true solution lies.

The main problem with which the panel is dealing may be stated in a series of questions:—Why does it require a large number of alternations of strain to cause a fatigue fracture? Does this failure originate within a crystal or between the crystals; if within a crystal, does it begin in the middle or at a boundary? Does the failure occur in tension, or by shearing? How is the plane of the initial failure related to the axes of the principal stresses and to the crystal lattice (if it occurs within a crystal)? How is fatigue failure connected with hysteresis in elasticity? Till these fundamental questions are answered there exists no theoretical basis to guide us in the more practical problems, such as the methods by which the fatigue limit can be raised or the strength of over-fatigued metal restored, or to suggest how better alloys can be made.

One of the first questions dealt with by the Panel was the standardisation of nomenclature. This led to the clarification of our ideas and to the realisation of the importance of keeping a clear distinction between stress and strain. It is common practice to reduce measured strains in rather an arbitrary manner to corresponding stresses. Dr. Griffith pointed out serious errors which arise from this practice, and called attention to the fact that some fatigue machines really test the sample at defined stresses and some at defined strains and that the results may be expected to differ, which has since been confirmed experimentally. The panel now quotes fatigue limits in terms of strain rather than stress in many cases. Two initial difficulties have been overcome. There is no longer any need to doubt the reality of a finite fatigue limit. The results of early experiments gave no certain indication that the fatigue limit might not decrease continuously with the increase in the number of alternation of stress, but the recent long duration tests made in America and England leave little doubt on this point, and the fact that the metal is actually stronger (*i.e.*, has a higher fatigue limit) after a long test than it had at the beginning appears to clinch the matter. Again, the manner in which an initial microscopic failure spreads across the test piece has been fully explained mathematically by Mr. Southwell, so that the only problem to be solved is how the initial failure starts. Southwell's theory has been experimentally confirmed at the National Physical Laboratory by tests on samples with very small holes drilled in them to represent initial fatigue failures.

One of the practical difficulties in studying fatigue is that it takes such a long time to determine a fatigue limit. A single test, when run at the ordinary speed of 2,000 alternations per minute, requires 3½ days continuous running, and as 4 or 5 tests are needed to fix the limit the test may last a fortnight, though, with experience, this time may be reduced considerably. Search was, therefore, made for quicker methods of finding the limit. A successful method was found by Mr. Gough at the N.P.L. It consists in finding the limit of proportionality for a rotating test piece (Woehler), *i.e.*, the stress at which the deflection of the rotating test piece ceases to be proportional to the load. A mirror is fixed on the end of the Woehler test piece and accurately adjusted so that its plane is normal to the axis of rotation. A telescope and scale fixed in front of the mirror, and at a considerable distance from it, enable the deflections to be accurately observed. Gough found that the limit of proportionality determined in this way corresponded very closely with the fatigue limit determined by long runs in the ordinary way. The whole test can be completed in an hour, on a single test piece. Subsequent investigations, however, have shown that this test does not always give true results.

Another method of quickly finding the fatigue limit was then investigated. Hopkinson had pointed out that there should be rapid rise of temperature of the test piece when the fatigue limit was passed owing to hysteresis, so Mr. Gough, Professor Haigh and Dr. Griffith made experiments on these lines. The results were quite unexpected. It was found by Haigh, when nickel was tested in this way, that there were a series of "heat bursts," or sudden evolutions of heat which rapidly died away again, as the load was steadily increased. The same phenomenon was afterwards observed with other metals, *e.g.*, in hard steels, though not so strongly marked. Griffith found that in Armco iron heat was generated at quite low stresses, and that there was no marked increase when the fatigue limit was passed. Gough also found that the heat generated gave no clear indication of the fatigue limit. These results confirmed earlier tests by Rowlett, who had shown that there was elastic hysteresis at quite low stresses. Griffith's method of testing is particularly elegant, as it enables him to photograph the load strain hysteresis loops while running the test and simultaneously to measure the heat generated.

A third investigation, on somewhat similar lines, has been made by Professor Mason, though with a rather different object. Mason measured the amount of work being put into the Woehler test piece by an extension of Gough's method of measuring the deflection. If work is being put into the test piece, its deflection will not be exactly vertical, but slightly to one side. The sideways deflection measures the arm of the couple doing work on the specimen. Mason measured this sideways deflection. His results confirm the fact that there is no sudden change in the work being done on the test piece at the fatigue limit. No general method has so far been found for quickly finding the fatigue limit, though Gough's method can be used successfully in many cases and the high-speed tests referred to later require only about an hour each.

Whilst experimenting with Gough's mirror apparatus, Professor Lea found that the limit of proportionality could be raised (some 30 per cent. in his samples) by removing the load and then re-applying a slightly larger load. He showed that this change represented a real raising of the fatigue limit. Gough has extended these experiments and has succeeded, by a slightly different procedure, in raising the fatigue limit still further. It appears that the metal is hardened in some way by fatigue, if the strain is not excessive. This fact has also been demonstrated by Dr. Aitchison, who showed that the Brinell tests were higher on metal that had been fatigued. The action, at first sight, appears to be somewhat analogous to the strengthening of metal by cold work, but it must be remembered that in the fatigue tests the dimensions of the test piece are unaltered, and there is nothing analogous to the rolling down or wire-drawing process used in applying cold work. A possible explanation of the hardening produced by fatigue is given in Gough and Hanson's paper referred to later.

Numerous failures in aeroplane engine parts had drawn attention during the war to the importance of concentrations of stress at fillets, screw threads, oil holes and other parts where sudden changes of shape occurred, and theory appeared to indicate that under alternating stresses fatigue failures ought to occur at such points when the mean stresses in the neighbouring metal was far below the fatigue limit. There appeared to be no reason why such failures should not occur even though the sharp corners were very minute; in fact, scratches of microscopic dimensions might start fatigue cracks, which, once started, must spread. An investigation of this problem was therefore made in my laboratory by Mr. Thomas. Scratches were made by diamond points and by very finely ground steel tools; their shapes were accurately determined by making gelatine casts of the scratches and then cutting microtome sections of the gelatine and photographing them under the microscope. As a result it was found that the weakening effect of the sharpest scratches did not exceed 30 per cent.—a sufficiently serious reduction of strength though far less than theory had suggested. By comparing the shapes of the scratches made by files and emery, an estimate was made of the effect of various styles of machine finish on the strength of the metal.

Another series of investigations bears on this subject. Taylor and Griffith have shown how to find the stresses in a shaft with a keyway cut in it by their elegant soap-film method. Tests to confirm this theory have been made at the N.P.L. and show good agreement with the theory. But the effect of the keyway in weakening the shaft when subjected to alternating torque is not nearly so great as theory would indicate, when account is taken of the sharp corners at the bottom of the keyway. The effect of the concentration of stress at these corners is of the same order as was found for the scratches. Various explanations of the discrepancy between the theory and the experiments have been offered, but the matter is not yet fully explained.

While facts were being accumulated in these ways, theoretical explanations of the nature of fatigue failures were being sought for. The author elaborated a theory based on Ewing and Humfrey's work which showed that the failures originated by the backwards and forwards slipping of two parts in an over-stressed crystal. It was shown that all the known facts could be explained by a very simple model, and the closeness with which the model reproduced large numbers of experimental results was remarkable. Several new phenomena were foretold which were subsequently verified by experiment, and it seemed that the fundamental problem had been solved. But this expectation did not last long. Griffith showed that Armco iron possessed properties which were inconsistent with the theory. He found that in Armco iron the fatigue limit is considerably higher than the yield point—a very puzzling fact. Another investigation made by Gough and Hanson at the N.P.L. on the production of slip bands proved that, so far as could be seen, slip bands did not allow backwards and forward motion—but were produced by motion in one direction only. This negatived Ewing and Humfrey's explanation and brought down my theory which was based on it.

Hopkinson showed, many years ago, that metals were elastic up to their ultimate strength if the load was applied quickly enough, and suggested that the fatigue strength would also go up if the rate of alternation were increased. To test this hypothesis, I have carried out tests at periodicities varying from 50 to 2,000 periods per second (*i.e.* 120,000 per minute), and find that the fatigue limit does rise with the increased periodicity. This result has an important bearing on the theory of fatigue failure, for it means that distortion requires time—some action like viscosity or phase change must be involved in the very small strains which accompany fatigue failure. Griffith has suggested that fatigue failure is really a manifestation of phase changes occurring in the individual crystals. He suggests that there may be several phases within one crystal—not distinguishable by changes of the lattice frame. This theory is not fully worked out yet, but he has already brought forward much evidence in favour of it. He has worked out a new method of etching which reveals an internal structure in the crystals which is consistent with the theory. The rise of the fatigue limit with periodicity just referred to is explained by this theory.

Professor Haigh, though he does not offer any detailed theory of fatigue, considers that the problem should be dealt with on a dynamical basis with the help of the laws of thermodynamics, and has collected much evidence that is very suggestive. Theories based on the amorphous cement theory have been much discussed and have many supporters, notably Dr. Rosenhain, but, so far, no complete explanation based on this theory has been worked out. Professor Lea has made fatigue tests at high temperatures and has shown that the fatigue limit of steel rises some 25 per cent. at temperature of 400 deg. C. Haigh has obtained similar results with cast iron. Annealing at quite moderate temperatures has been shown to modify the behaviour of steel under fatigue—for example, if stress-strain curves are plotted by Gough's method it is found that overloading the sample lowers the limit of proportionality (rotating) and that boiling the over-fatigued sample in water raises the limit far above its original value. These limits of proportionality, however, do not any longer coincide with the true fatigue limit. The meaning of these results is doubtful.

An important investigation into the strength of springs—which is, of course, a fatigue problem—has been begun by Lea, who has already arrived at some results. This work has now been transferred to another panel which is dealing exclusively with springs. Dr. Aitchison has investigated a practical problem of some importance on the effect of improper heat treatment on the fatigue limit of certain steels. He is also just completing an investigation of the effect of the direction of the grain in steel (as shown by its macrostructure) on its fatigue limit. A great deal of work has been done recently on the Continent and in England on the changes in the lattice structure of crystals, which takes place when the metal is cold worked. G. I. Taylor's Bakerian lecture on the distortion of a single crystal of aluminium has given rise to great hopes that X-ray analysis of crystal structure may throw much light on the nature of fatigue, and fatigue tests on single crystals of aluminium are now being made at the N.P.L. with the co-operation of Professor Carpenter and Miss Elam. If the metal consists of an aggregate of crystals and amorphous cement, it seems necessary to investigate the fatigue of amorphous material as well as of single crystals. Experiments on vitreous silica are being made by Griffith, and I have made tests on sealing wax and am about to test synthetic resin (Bakelite). These researches are not sufficiently advanced yet to enable any conclusions to be drawn from the results. It does not seem possible to push our investigations closer to the ultimate constitution of the metal.

The problem is fascinating—who will find the answer? Will one of our hosts on this side of the water speak the word that will set all these diverse phenomena in orderly array?

* Read before Section G of the British Association at Toronto on August 11, 1924.

TRAMWAY TRAFFIC RECEIPTS.—Official returns of 34 of the principal tramway undertakings in the United Kingdom, as published by *The Tramway and Railway World*, give the total receipts, for the week ending July 19, of 343,927*l.*, or 9,532*l.* more than was received for the corresponding week of last year. This means an increase of 4*l.* 17*s.* 10*d.* per mile of track open.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

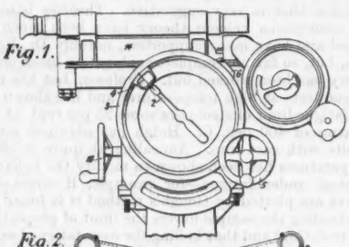
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

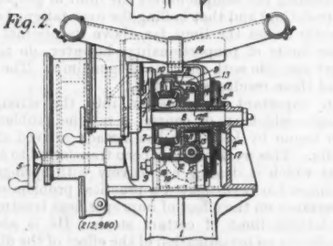
The date of the advertisement of the acceptances of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GUNS AND EXPLOSIVES.

212,980. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, and R. Morrison, Newcastle-on-Tyne. Sighting Devices for Director Firing. (2 *Figs.*) December 18, 1922.—The invention relates to fire-control apparatus in which differential gear is employed to add to, or subtract from, the amount of movement corresponding to any particular range-setting, the amount of movement corresponding to the displacement of the layers, telescopic or other sight, in keeping on the target, the added movements being conveyed to out-stations by a transmitter. In a director sight constructed according to one feature of the invention, the transmitter is connected to one element of a differential gear and range-setting mechanism to a second element of the differential gear, while the director sight is connected to the third element of the differential gear through irreversible gearing, such as a worm and worm wheel. According to another feature of the invention, one bevel wheel of a differential gear is actuated by the range-setter or is automatically controlled from a range-finding or other position. The other bevel wheel of the differential gear actuates means for transmitting movement to an indicating dial at out-stations, and the director sight is connected, preferably through irreversible gearing, to the spider or cage carrying the bevel pinions. 1 is a pedestal, 2 is a range pointer actuated in a known manner from an outside control station by means of a step-by-step motor. 3 is a ring having a scale 4 thereon and connected by gearing to a handwheel 5, which is actuated by the range-setter, who keeps the index 4 opposite to the pointer 2. 6 is an arm which is connected to the ring 3 and has

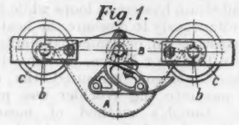


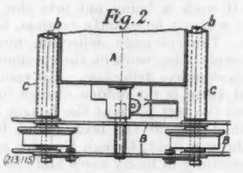


fast on it a bevel wheel 7 forming part of a differential gear and rotatably mounted on a shaft 8 in a casing 9. The bevel wheel 7 is in mesh with pinions 10, which, in turn, are in mesh with the second bevel wheel 11 of the differential gear, which bevel is also rotatably mounted on the shaft 8. The pinions 10 are carried by a spider 12, which is rotatably mounted on a sleeve or prolongation 11*a* of the bevel wheel 11. 13 is a worm wheel fast on the spider 12. 14 is a telescope support keyed to a sleeve or prolongation 12*a* of the spider 12. The worm wheel 13 is in mesh with a worm 15 which can be rotated by the layer through a handwheel 16. 17 is a gear wheel fast on the sleeve 11*a*. In operation, when range is received from an outside control station, the pointer 2 is rotated. The range-setter, by turning the handwheel 5, keeps the index 4 on the ring 3 opposite to the pointer 2. In so doing, the bevel wheel 7 is also rotated through the arm 6 which transmits movements through the differential gear to the gear wheel 17 and consequently to the switch 18, which latter transmits to receiving instruments at the out-stations, movements corresponding to the elevation required by the gun for that range. During this operation, no angular movement is given to the telescope support 14 about the shaft 8. When the layer rotates the handwheel 16 to keep the telescope on the target, the worm wheel 13 and spider 12 connected thereto are rotated. The spider through the pinions causes the rotation of the bevel wheel 11, and consequently effects a rotation of the transmitting switch 18, which latter transmits to receiving instruments at the gun a vertical angular movement corresponding to the angular movement of the telescope. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

213,115. H. J. Toogood, Elland, and Robert Dempster and Sons, Limited, Elland. Gravity Bucket Conveyors. (3 *Figs.*) March 22, 1923.—The invention relates to a non-spilling gravity bucket conveyor, and according to the invention, the space between each two adjacent buckets is closed by a member which is maintained in a state of suspension between the main chains of the conveyor in such manner that it can move laterally in any direction of movement of the chains. A indicates the buckets and B the endless chains which carry them. Each closing device comprises a tube or hollow cylinder C through which each rod *b*, which connects the two endless chains B together, passes. The tube is made sufficiently large in diameter to close the space between two adjacent buckets and it can move in a lateral direction if required when the buckets are travelling around a curved path so that it will not bind upon them and interfere with their movement under the action of gravity. The tilting or righting device comprises a spring supported block placed at a suitable angle and having its face hollowed out to correspond to the path described by the buckets A as they travel in orthodox manner around a curve. As long as the buckets keep level when rounding the curve they just clear the hollow face, but in the rare event of their becoming tilted before they arrive at the righting device the buckets are so proportioned that their bottom portions engage the latter, with the

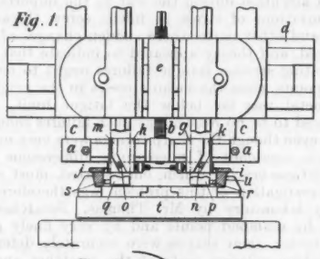


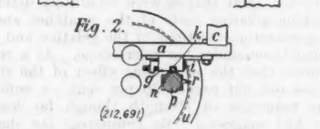


result that the buckets are restored to a level condition as they pass over the concave surface of the righting device and thus none of the contents are spilled. The block may be constructed from wood and is carried by bolts which may make a sliding fit in a metal block carried by one or more angle irons, or other supporting members, compression springs being interposed between the wood and metal blocks. The conveyor may be fed with material by means of an ordinary shoot. The buckets are discharged in known manner by cams on the ends of the buckets which engage a trigger arranged where desired along the path of conveyor. These cams are so designed as to upend the bucket and right the same in a relatively gentle and noiseless manner. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

212,691. C. D. Andrew, Buxton, and Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne. Boring and Turning Mills. (2 *Figs.*) January 18, 1923.—The invention relates to machines of the type wherein the work, such as a steel railway tyre, is mounted for rotation whilst a plurality of tools and tool holders enter the tyre to perform the required sequence of operations, such as rough and finish boring and recessing or grooving. A cross stay *a*, carried by the lower end of the screwed pillar *b* by which its vertical position is adjusted and determined, is adapted to be secured, when in the position desired, to the usual uprights *c* carrying the ordinary cross slide *d*. The screwed pillar *b* is carried in the saddle *e* upon the cross slide *d*. By turning the pillar *b*

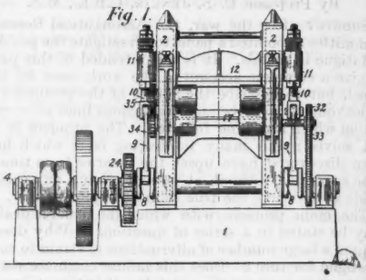


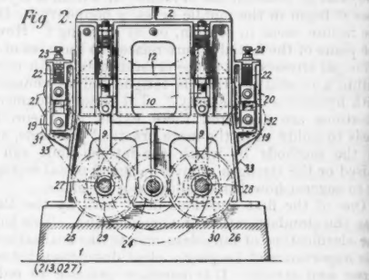


in the saddle *e*, after the stay *a* has been released from the columns *c*, the stay can be raised or lowered. The cross stay *a* carries two tool slides *g*, *h*, the one *g* carrying a roughing tool *i* for the recessing operation, and the other *h* a finishing tool *j* for the same operation. Each of the slides *g*, *h* has a cam groove *k*, *m* therein, into which enters a pin, *n*, *o* with a roller thereon carried by the ordinary tool holders *p*, *q* of the boring mill. With the construction described, when the boring tools have performed a portion of the boring operation, the rollers on the pins *n*, *o* enter the inclined portions of the cam grooves *k*, *m* and impart outward or feed movements to the recessing tools. When the parts *n*, *o* are clear of the cam grooves *k*, *m*, the slides *g*, *h* may be returned to their out-of-service positions by springs (not shown). (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

213,027. W. Jones, Swansea. Flattening, Stretching and Straightening Sheets. (3 *Figs.*) January 4, 1923.—The invention relates to a machine for flattening, stretching and straightening sheets and plates. According to the invention, the machine comprises a power-driven hammer and anvil on which the plate or sheet is flattened, and feed and delivery rolls by means of which the plate or sheet is moved through the machine. The machine comprises (*inter alia*) a base plate 1 and two main frames 2 bolted to the base plate. In the lower part of the machine a main driving shaft 4 is journalled on the base plate 1. At one end, the shaft is provided with a pinion 24 engaging with gear wheels 25, 26 on subsidiary shafts 27, 28. The shafts 27, 28 are provided with cranks 8, which carry connecting rods 9 pivoted to forked-end rods 10, which pass through ears or lugs 11 provided on the hammer 12. The hammer slides in guides between the main frames 2. The anvil or die 17 is mounted on a resilient bed to deaden shocks. At each end of the main frames 2 are mounted brackets 19 in which feed rolls 20 and delivery rolls 21, respectively, are journalled. The pressure between the rolls is adjusted by springs 22 and adjusting screws 23 and the line of contact of the rolls is, of course, level with the surface of the anvil 17. For driving the rolls, the following gearing is preferably provided. The subsidiary

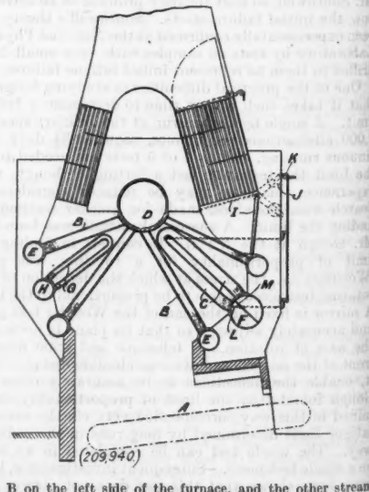




shafts 27, 28 carry gear pinions 29, 30, respectively, which drive by chains 33 similar gear pinions 31, 32 on the spindles of the lower rolls of the pairs of rolls 21, 20, respectively. For driving the top rolls, inter-engaging gear pinions 34, 35 are provided on the roll spindles at the other ends of the rolls. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

209,940. H. E. Yarrow, Scotstoun, near Glasgow. Steam Re-heaters. (4 *Figs.*) January 11, 1923.—The invention relates to devices for re-heating steam between successive stages of expansion in a steam turbine, of the kind in which the re-heater is interposed in the path of hot gases, which can be diverted or deflected along another path by means of a damper. According to the invention, a damper controlling the flow of the hot furnace gases amongst the re-heater tubes is held in the open position, in which the furnace gases pass freely, by means of a latch which, through suitable linkage actuated by a thermostatic device, is tripped to release the damper, which then gravitationally assumes another position in which the flow of furnace gases amongst the re-heater tubes is diverted completely or to a definite extent. A represents the furnace grate, B the steam generating tubes, C the re-heater tubes, D the steam and water drum, and F the re-heater drum. The furnace gases normally pass in divided streams around both sides of the steam drum D, one stream traversing the superheater tubes G and the generator



tubes B on the left side of the furnace, and the other stream traversing the re-heater tubes C and the generator tubes B on the right side of the furnace. A damper I provided on the re-heater side, and normally open, as shown in full lines, is arranged to be closed automatically when the temperature of the re-heater reaches the limit of safety. The damper I has a counterweight J, which is normally held in an elevated position by a latch K, but when this latch is tripped, the counterweight drops and brings the damper I into the position shown in dotted lines, in which the uptake on the re-heater side of the furnace is closed and the gases which would otherwise traverse the tubes on that side pass to the uptake on the other side of the boiler. The latch may be tripped by means of a thermostatic device of known character depending upon the differential expansion of two rods L, M, one of which may be of the alloy known as Invar, which has a low coefficient of expansion, while the other may be of copper or other metal or alloy having a comparatively high coefficient of expansion. These rods are so disposed that they assume the temperature of the re-heater tubes or of the re-heated steam. (*Sealed.*)